THE AMERICAN GAS LIGHT JOURNAL

REDMAN & KENNY, N.Y.

PUBLISHING OFFICE No. 42 PINE STREET

DEVOTED TO THE INTERESTS OF ILLUMINATION, HEATING, MECHANICAL, CHEMICAL AND GENERAL SCIENCE

VOLUME LXXVIII. No 25. Whole No. 1,463. | NEW YORK, MONDAY, JUNE 22, 1903. | $3 PER ANNUM, IN ADVANCE.

A. M. CALLENDER & CO., Proprietors. C. E. SANDERSON, Manager. THOMAS J. CUNNINGHAM and ELBERT P. CALLENDER, Editors.

ENTERED AT THE POST OFFICE AT NEW YORK, N. Y., AS SECOND-CLASS MATTER.

Published on each Monday of the year, at No. 42 Pine Street, New York.

Telephone.—2996 John.

Terms of Subscription, Including Postage.—For the United States and Canada, $3 per annum. European countries, $5 (£1—25 francs). All payments to be made in advance. Single copies, 10 cents.

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BRIEFLY TOLD.

MR. JOHN SOMERVILLE ON THE MAXIMUM ECONOMICAL YIELD PER POUND OF COAL CARBONIZED: AN APPRECIATION.—It seems almost a pity that Mr. Somerville's data could not have been in my hands when my paper on "Naphthaline," for the Indianapolis meeting of the Western Gas Association was being written, or it may be that still more productively, my manuscript in his hands. The two papers could both have aided, each in the production of the other. In preparing his paper Mr. Somerville must have collected many items and valuable data, bearing on naphthaline production, and his results so well illustrated those of my experiments that he could well say, "My statement of results explains his findings;" for nothing could better illustrate the pecuniary folly of a process whose false logic I attempted to enforce.

His statement, "There can be no question (but) that there is a maximum useful yield," might be well qualified at once by a clause which appears in the next paragraph. This clause is, "To some extent the question is one of locality."

It is very greatly one "of locality." It is also one of the candle power required, of the kind of burner used, and of the proportion of the mantle consumption to the consumption of the amount used for power and the like, all which in a group may be covered in by the one word "locality."

In preparing my paper for Indianapolis my business was "naphthaline," but there was an abundance of evidence that an antithesis existed between the amount and the quality of the gas made; and also that, within certain limits, calorific energy and luminosity were inverse functions of the yield. It is also easy to demonstrate by laboratory methods both the fact that quantity can be increased at the cost of quality (calorific energy and luminosity) and also *the reason* for this fact.

The experiments made to get the facts for the Indianapolis paper proved to demonstration that while the bulk of the gas obtainable from many coals was remarkably increased by prolonged heating and high temperatures, the illuminants in the gas were not increased by such treatment; but to the contrary they *were decreased*, not only relatively, *but actually*. Apparently the theory of high heats is the conversion into acetylene (Lewes). The actual result is naphthaline and ethane, except at a temperature within very narrow limits at which benzole and acetylene are indeed formed in the presence of free hydrogen, just as Prof. Vivian Lewes alleged. But in the gas works such a result can only be obtained by chance-medley, since the proportions of the ingredients in the required mixture cannot at present be predicated in the gas works, and the exact temperature cannot be even guessed at; the more since even in the laboratory the experiment miscarries nearly one time in five. It is not my intention to discuss this question now, as I intend to put these facts into a logical form in another paper.

From the standpoint of my studies it seems certain that the economically successful yield is largely a question of locality, for in one local environment the illuminating power stands before all other characteristics, and 50 miles away may be a works in which the illuminating power plays but a small part.

It is delightful to see that Mr. Somerville has so clearly appreciated the fact; and what is more, has utilized it—the fact which I have insisted

LIBRARY OF CONGRESS, JUN 22 1903, SMITHSONIAN DEPOSIT.

on so many times, that if ideal results are to be obtained in gas making, it must be remembered, first, last and all the time, that the gas works is essentially *a huge chemical laboratory*, and the gas works' manager a manufacturing chemist, in a very large business, and that he should have the same means of controlling his operations which any other chemist has.

This fact Mr. Somerville has seen, and he has not only seen it but has also acted upon it; for it is only in a works in which laboratory methods are used with constancy and precision that results such as he has gotten are obtained; and how pitiful it is that he has not some means of controlling temperatures equal to the needs of his skill in experimenting. Were he but a young man how much we could expect him to do for chemistry, both science and art. Let us congratulate ourselves on what he may yet do, if he but has the will to do it.

Were all the papers read before our American societies as "meaty" as this one, how often would one sit with an American periodical on his knee before the fire considering the lessons therein enforced, instead of throwing it one side to pick up a journal in a foreign tongue. It seems almost too bad that the report of his work does not contain a little more information since it contains so much. Why did not Mr. Somsrville send a sample of the coal to some chemist so situated that he could supplement Mr. Somerville's paper with the distinctly scientific data, the analyses of the coal and of its various distillation products at various temperatures?

Had analyses of the coal, and gas made from it, been prosecuted with all the latest laboratory refinements, the paper would have shown *the details* of the differences in composition which were the causes of the differences in the results obtained from the gases made at the two temperatures. So great a difference in candle power implies the existence of some facts which need to be widely known.

Mr. Somerville certainly has won the gratitude, he already had the respect and esteem, of the "chemists," who just now seem to be so very little honored by the "practical men," and who in turn are pursuing their studies with too little regard for what the practical men are doing. I am confident that I speak by the book when I say that all the ehemists interested in gas making will wait most impatiently for Mr. Somerville's next paper on this important subject.—W. H. BIRCHMORE.

NOTES——

DURING the 47th annual commencement of Tufts College, Boston, Mass., the exercises having been held in College Hill the 17th inst., the title of Honorary Master of Arts was conferred upon Mr. James Dudley Perkins. May the famous "gas coal baron" long live to enjoy the honor conferred by the house of learning of his early days.

THE City Council of Springfield, Ills., has refused to issue a franchise to the promoters of the Consumers Gas Company, who sought to operate an opposition gas works in the placed named.

THE Massachusetts United Gas Companies have purchased outright the properties and rights of the Chelsea (Mass.) Gas Company.

A CORRESPONDENT forwards the following from Delray, Mich., under date of the 13th inst.: "A shareholders' meeting of the Detroit Suburban Gas Company was held in Delray yesterday at which $240,000 of the stock was represented. The Directors were authorized to purchase 2 miles of 8-inch pipe and three carloads of gas stoves. It was decided to retain Mr. William H. Frost indefinitely as General Manager of the Company. Mr. Frost was authorized to procure sectional maps of the Company's property. The action of the Manager in bidding for the lighting of Woodmere streets with gas was approved. General Manager Frost reported that since the change in the Company, April 23, 1903, he had laid 5 miles of mains, had set 250 stoves and had connected up 290 additional consumers, and that orders for 128 connections were still to be filled. Treasurer M. A. Lander reported that $34,000 of the outstanding obligations of the old organization had been paid to various persons and that he still retained in the treasury $40,000 in cash. He further stated that the Company had not sold any of its $60,000 of treasury stock. The question of reducing the price of gas came up for discussion but no action was taken. Manager Frost was authorized to secure estimates for additional benches and for a gasholder up to a a capacity of 250,000 cubic feet."

THE Cincinnati (O.) Gas and Electric Company has awarded a contract to the Western Gas Construction Company, of Fort Wayne, Ind., for the placing of three sets of purifiers, 26 feet by 26 feet by 11 feet 6 inches, of the Western Company's type of duplex construction. The boxes are to carry the contractors' plan of dry seal covers. The agreement further is that the placing will be completed within 90 days of the signing of the contract.

[OFFICIAL REPORT.—REVISED BY THE SECRETARY.—Continued from Page 931.]

TWENTY-SIXTH ANNUAL MEETING, WESTERN GAS ASSOCIATION.

HELD AT INDIANAPOLIS, IND., IN THE CLAYPOOL HOTEL, MAY 20, 21 AND 22, 1903.

SECOND DAY—MORNING SESSION.

The President introduced Dr. W. H. Birchmore, of Brooklyn, N. Y., who prefaced his lecture on

NAPHTHALINE

with the following remarks:

Before I begin I wish to say a word in behalf of my devotion to the analysis of illuminating gas. I have been told half a dozen times during the last year that I laid altogether too much stress on the careful analysis of illuminating gas, and that the books did not take any account of some 15 things which I said could be found in gas if people would take a little time to find them. It has come to my knowledge again this morning that the same protest of unnecessary carefulness has been made to some work which I have just printed. I beg leave to state again that the analysis put down in Hempel is only a scheme to be worked through just as fast as a man can. It groups all the paraffines as methane groups, the $C_n H_{2n}$ as acetylene. In the last edition of Abady's book he draws attention to the fact that two more of the ethylene group may be isolated without a great deal of trouble. The fact is there are 16 ingredients to be gotten out of almost any gas if you will just take a little bit of trouble. Excuse me for talking about a thing of that kind, but it came to me this morning in a way that I thought I could not overlook.

Having thus cleared his mind, the Doctor went on with his subject proper:

Gentlemen: We may begin this paper and its discussion by asking, "What is this substance, naphthaline?" which is everywhere held as a *bete noir* of the gas works manager.

Perhaps the best statement of the chemical nature of naphthaline accessible to everyone is that in that in Bernthsen; "Organic Chemistry" p. 498. This author gives in admirably concise statement the following information: "That portion of coal tar which boils at a high temperature, contains a number of higher hydrocarbons, among which may be specially mentioned naphthaline ($C_{10} H_8$), anthracene ($C_{14} H_{10}$) and its isomeride phenanthrene. The first named is found in the fraction between 180° and 200° C., and the two latter between 340° and 360° C. These compounds are of more complex composition than benzene, the molecule of naphthaline differing from the latter by $C_4 H_2$, and those of anthracene and phenanthrene from that of naphthaline by the same increment. They show, however, the most complete analogy to benzene as regards behavior, so that almost exactly the same varieties of compounds may be derived from them as from benzene itself."

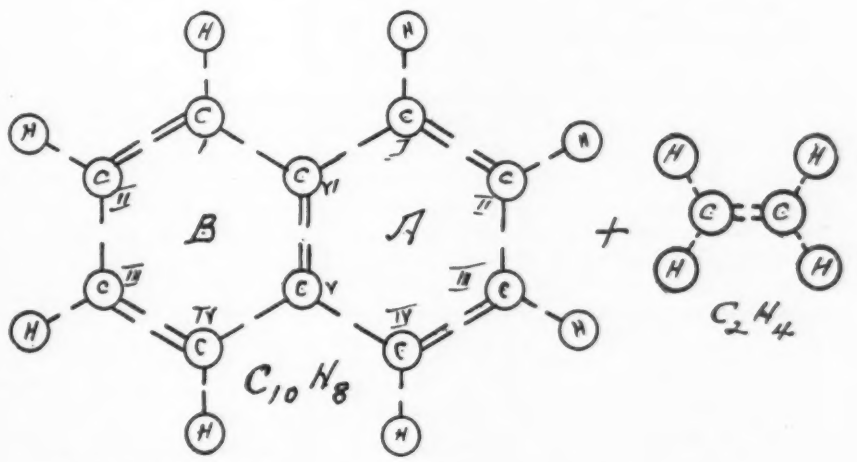
The importance of this statement is great. It, so to say, marks for us the locality at which this inquiry must begin, and it also conveys certain important information. It tells us that the two points between which naphthaline distils are very near each other. It says, "Naphthaline is found in the fraction distilling between 180° and 200° C. But this small range is not due to a high melting point. Pure naphthaline melts at 80° C., less than the temperature of boiling water, but to the intense mutual grasp of this hydrocarbon and its solvents, or those which mutually dissolve and are dissolved by it, upon each other, which makes it so hard to part them.

Transforming these temperatures into those of the common scale, we see that naphthaline distills between 356° and 392° F. This gives the limits between which naphthaline is held in solution as a vapor condensed to fluid as 20° C. and 36° F., a very small temperature range indeed. The quotation continues: "As a matter of fact they (*i. e.*, naphthaline and the two isomeres mentioned) are undoubtedly benzene (benzol) derivatives. From their modes of formation and from their behavior it follows that, in the building up of their molecules, the benzene (benzol) residues combine together in such manner that two, or twice two, carbon atoms are common to both of them." Be pleased to note this statement, that each molecule of naphthaline stands for the destruction of two benzene molecules, two molecules of a substance almost the most valuable to the gas maker, and the incorporation of the residues in a single molecule of this troublesome substance, which we are in practice almost compelled to eliminate as a common nuisance.

Consider for a moment what this mode of naphthaline formation may imply. We have reason for thinking that sometimes, if not frequently, the practical luminosity, as measured at the gas works on

the photometer, as well as the available heat in quite too frequent instance, falls far below the laboratory calculations, calculations based on the results of the analysis of coal and of the gas obtained from the coal, by the laboratory process as employed by chemists making use of the laboratory apparatus. This failure to agree had so often occurred within my experience that I was beginning to doubt the accuracy of the values given to the constants used, for my results were always too high. . But, after much seeking in vain to find it, an opportunity offered to make a comparison between the amount of naphthaline and benzene yielded by a certain sample of coal, which I had examined with special care. When this coal was distilled in the laboratory apparatus to make a sample of gas in order that a study might be made of the product, and the amount of the naphthaline and benzene in the gas made at the gas works from the same coal, of which gas also I had samples taken at various points in the system, a discrepancy appeared, and when it was "worked back" the fact stood out as plainly as any fact could stand that more than 65 per cent. of the benzene which was present in the gas made with my experimental apparatus had somehow disappeared, and that there was more naphthaline in the gas than I could prove to be present in the coal, even allowing that the lost benzene had all gone to make naphthaline. But this only adds a new term to the series, for even if the lost benzene had been converted into naphthaline, thus accounting for the increase in amount of this substance, why did the naphthaline thus formed find its way into the gas; why was it not held back in the heavy oils, or in the tar? To answer this question, to give not an answer which can be at best only partly true and may be wholly false, but to give the answer which tells the whole truth and leaves nothing more to be said, is to have the clue to the solution of the whole problem, is to have the problem of eliminating the naphthaline plague very much in hand.

It is but a fair inference, from general experience and the loss of available benzene, to say that somehow and somewhere in the process of gas making two benzene rings are broken up, and that the "residues," the broken rings united, so far as they remain coherent at all, form the naphthaline fetter, this undesired by-product which we are considering. We may, therefore, ask as our first question, "What are the reactions among the gas ingredients leading up to the formation of naphthaline and other like hydrocarbons?" We may form some opinion by study of the question in the laboratory, by experiments in synthesis and corresponding analysis and the after investigation of the results; but before we undertake the discussion of the results which have been attained by such examinations it might be well, in the interest of a better understanding of the chemistry of the problem, to spend a few minutes in discussing the symbolic representation of the molecules, of the signs used to represent the constituent sand grains which make the mountain of the substance, this naphthaline, which we have under consideration.



$2C_6H_6 = C_{10}H_8 + C_2H_4$.

Fig. 2.

This symbol *A* represents a dextrotype, right-handed benzene ring; that is to say, it is the glyph used to represent a benzene ring in which the order of the numbers, given by common consent to the groups of atoms, agrees with the order of the numerals on the face of a watch. There is another type possible, the sinistro-type, left-handed ring *B*, in which the numerals applied to the atoms groups read in the reversed order to that of the hands on a watch. On examination we note that in both rings the carbon atom is always quadrivalent; that is, it unites with four univalent atoms, and we also note that one atom of hydrogen always satisfies one valence of the carbon atom, the so-called centrifugal or external one. Consequently the various carbon atoms cannot be joined in every case with the same number of bonds; but since each atom of carbon has an even number (4), we must suppose that they are bound to each other alternately by one and by two bonds, or bands or affinities, whichever one is pleased to call them. Any name may be used as long as its meaning is understood to be figurative. The bonds are known to exist, and we use words having mechanical meanings, but the bonds are not mechanical. For reasons which are perfectly valid we are certain that the union is physical, whatever its character; and in this sense the bonds might be considered to be mechanical; but when we use the word "link," "chains, "ring," "fetter," and a host of others, the language is purely figurative. It is believed, for reasons which need not be discussed here, that the double bonds form the union between *I.* and *II.*, *III.* and *IV.* and *V.* and *VI.*, while the atoms *II.* and *III.*, *IV.* and *V.*, and *VI.* and *I.* are joined by only one bond. In the dextrotype ring the atom numbered *II.* is on the right hand of that numbered *I.*, while in the sinistro-type ring the order is reversed and the atom *II.* is on the left of No. *I.*

This diagram represents the naphthaline molecule in the same way, and as we call the other the "benzene ring," so we call this the "naphthaline fetter," or "handcuff," names introduced to bring the picture more readily to our minds. As there are two benzene rings, so we might expect as many shapes of fetters as there are pairs of carbon atoms with the double bond, but since we must consider that naphthaline molecules have unions between like pairs of carbon atoms, if we intend to explain their existence methods we are forced to believe that only one naphthaline is possible. In this case we see that two carbon atoms have places in each of the two component rings. If we consider the naphthaline fetters as made up by the union of two benzene rings of unlike name, one dextro-type and one sinistro-type, as has been proposed, then we must also infer that two carbon and four hydrogen atoms have fallen out of the benzene rings previous to their combination to form one naphthaline molecule. If such has happened two sorts of unions might take place, and very simple or very complicated molecules might result. This matter is a very important one in the chemistry of the problem, and must be taken up in detail later on; and probably ethylene is formed, as shown in Fig. 2, as well as naphthaline.

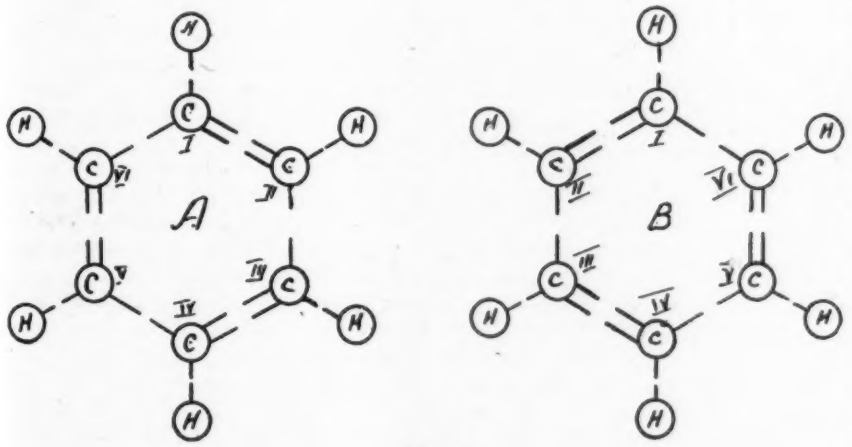


Fig. 1.

Consider for a moment some of the physical facts in relation to the benzene ring. We have spoken of the order of the atoms, and of the so-called twin bands, but there are a few points which concern us. You all know that the empirical formula of benzene is C_6H_6, that each of the molecules contains 6 atoms of carbon and 6 atoms of hydrogen, and you all know how they are supposed to be linked.

If we turn to the fetter you note that it is made up of two benzene rings, of opposite name, hence we can only have as many naphthaline fetters as there are *pairs* of the rings, and, therefore, we must have fewer molecules, and the naphthaline, since it contains more matter,

must be heavier than the benzol from which it is formed in the same proportion. We consider their form to be represented by the interlocked circles (the fetter), just as we consider the benzol to be represented by the ring. We also infer that just previous to the union of the two rings one was more disturbed than the other, and that sometimes the ring on the right, and at other times the ring on the left, is the one which is shaken the more. From various considerations of this order, and various experiments made along the lines such considerations suggest, chemists have formulated two propositions, alternative expressions of the facts observed: (1) Naphthaline may be, probably is, a *direct derivative* from two benzene rings of opposite name, one of which rings is more shaken than the other; or (2), the naphthaline is caused by the union of two benzene rings in process of formation as it were, and not yet complete, which have united because of crowding instead of following their orderly evolution.

Nearly or quite all the schemes used for obtaining naphthaline, for the sake of studying its formation, depend on the selection of a suitable material and applying analytical methods, but there is one method depending upon synthetic processes which leads to results most interesting in their meanings.

In order that this experiment may have its due significance, please note this diagram. *A* and *B* are gasholders to which the gas can be

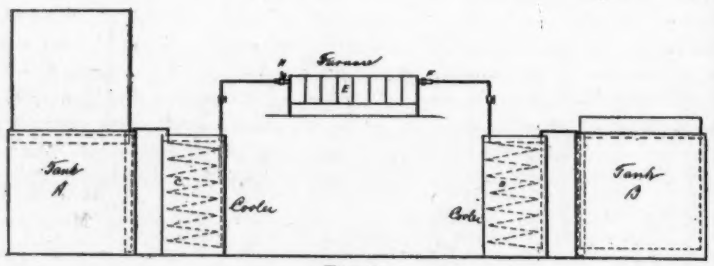


Fig 3.

passed back and forth from the filled to the empty at the need and pleasure of the operator; *C* and *D* are coils of glass tubing made to functionate as refrigerating apparatus by surrounding them with cold water; *E*, in which *F* is indicated, is a combustion furnace, and *F* is a tube of iron or porcelain nearly filled with pieces of coke about the size of large birdshot, but free from dust. The purpose is to obtain a large surface with which the gas shall come into contact.

A tube of iron may be used instead of porcelain, and as it is much cheaper, lasts quite as long as it is needed, does not quite but almost as well as porcelain, but it is not by any means without influence at high temperatures. Having got the apparatus together we fill the holder with the gas (holder *A* for instance), with which we intend to experiment, and having passed the gas carefully through the furnace to expel the air, which is allowed to pass out at the burner *H*, and at which burner, when sufficient air is expelled to make it possible, the gas is for a moment lighted, and as soon as the flame at *H* assures us that the apparatus is indeed air free, we pass some of the gas into *B*, so that an equal atmosphere may exist at both ends of the tube, and heat this tube and its contents in the furnace to various temperatures. It is only when the iron has been heated almost to a white heat that its inferiority to porcelain is manifest, and then its influence is plain enough, for very hot iron is by no means without action on hydrocarbon gases, and results obtained with an iron tube must always be accepted with a certain caution until they have been verified, have been obtained a second time with a porcelain tube or with one of platinum.

Having got the apparatus going let me turn to the same handy text book from which I quoted before and read a note on the formation of naphthaline: "*Formation.*—By exposing a large number of carbon compounds to a red heat; thus (together with benzene, styrene, etc.), by-passing the vapors of methane, acetylene, alcohol, acetic acid, etc., through red hot tubes." Excepting the dissatisfying presence of that unwelcome sign, "etc," nothing could be more satisfactory as a statement than this one. But we do not begin with passing pure hydrogen and the making of the methane, because it is possible but impractical. If we wish to make the higher hydrocarbons, as in the proposed experiment, it is always more simple to begin with at least a few atoms ready linked than to try to link *de novo*, for the sake of avoiding the time loss, if not for more serious reason.

This quotation tells us of the wide range of substances from which this hydrocarbon can be obtained, and assures us of its companions, and it also warns us to consider how diverse and how many its formation methods must be. The reactions which actually occur in our experiments in making naphthaline, as well as the by-products of the making, should never be regarded as analogous in any two series of reactions until this question has been submitted to examination and the fact of the analogy proved; much less should identity be assumed, for the widest divergence is in fact possible at any time. It does not require much experience with chemical investigations to understand that we have in hand one of those studies in which the results actually obtained by our experiments depend almost without exception upon the exact management and nice coincidence of conditions, and most important for success is skill in the nice details of the numerous manipulations. But since the conditions are almost exactly those of a retort in a gas works, the results are sufficiently interesting and important to justify any amount of time put in on the study. I believe I could spend hours instead of minutes in telling of the details of experiments made with such apparatus, and do so with profit. It would be increasing the fund of information at hand on the art of gas making, for the form of the apparatus is quite secondary; the fact of importance is the interaction of gases and coke.

It was my intention to avoid the use of the chemical notation, but to explain chemical facts we must use the language of chemistry, and, therefore, to an extent this notation must be used. However, I will explain all the glyphs and grams, and I promise to use them only when I find that I am compelled to do so, and when I do make use of this notation I will try to give full explanation of the symbols, and of the facts which they are intended to represent to the mind's eye.

You all know that the hydrocarbons are divided into two great series; those whose formula are indeterminate and those which have determinate formulæ. In the first series substances are changed from one to another by simply adding atoms or groups of atoms, but in the second series we must take the molecule to pieces to make a new one. That is, in the first series the formulæ, as representations of substances, have no definite limits within the series in respect to the number of atoms which combine; the other series presents for study many instances of such limits. We may express the same fact by saying that one series forms addition products and the other does not; that is, not in the same sense. Contrary as it seems to usual experience, however, it is certain that there is a transition between the two series of substances, and that this transition is possible at more than one place in the series, and that such a transition takes place in the experiment which I have described is perfectly certain. As the gas is passed once and again over the coke there is a change from one molecular form to the other. It is also a fact that, as we pass the red hot or white hot gas, for the gas in its passage is heated until it is as hot as the coke itself, most wonderful changes are produced by this mutual action both on the gas and on the coke. Sometimes the amount of hydrogen free in the mixture will be very large, and again it will be reduced almost to none at all; then, again, this gas will reappear, even in large quantity, the amounts of the various gases depending upon variation in temperature and the constant action of the law, that all molecules contain a maximum of hydrogen at the instant of formation, and all in like manner contain a minimum when they have become stable. When the free hydrogen disappears we always find that it has been engaged with carbon from the coke to form new molecules with a maximum of hydrogen, which molecules will in their turn go through the same series of changes from the less to the more enduring. On account of this power of the hydrogen atoms to react, a number of times in succession and each time with new atoms of carbon, it seems not improbable that a large part of the coke might be converted into the most complicated of the hydrocarbon forms found in illuminating gas, not into methane and ethane only, but even into "green oil" itself, were but time enough allowed.

We return to our apparatus and its uses. We fill it with a hydrocarbon easily made in the laboratory, and the least complicated of all hydrocarbons, one which has a molecule containing only one carbon atom. We fill it with methane, marsh gas. We pass this gas very slowly through the heated tube, so that it has time to come into the closest possible contact with the coke and to be heated to the same temperature. During the passage a great change takes place. We passed into the tube methane and a trifle of watery vapor, but we find that other than these come out of the tube. These changes we call synthetic reactions, and in the language of chemistry we express them thus: Watery vapor, coke and methane reacting, give opportunity for the formation of carbon monoxide, ethylene and ethane; hydrogen remaining free, and also carbon, with the most part of the methane unchanged.

As has been said this is the first reaction which can be surely said to occur, and it is well to consider it with some care, because it is in a way typical and simple itself; it foreshadows all the complicated reactions which are to come after it. Written with structural formula the reaction

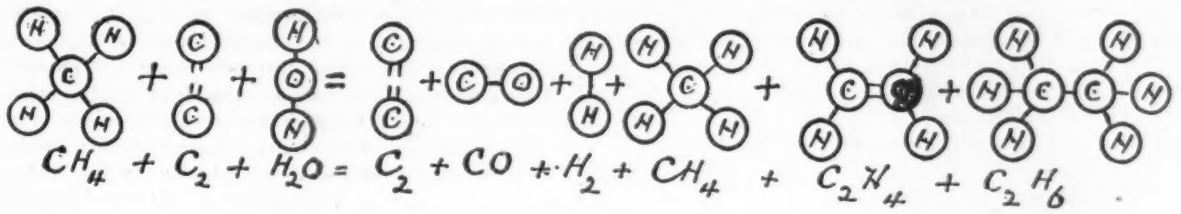


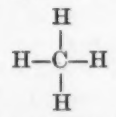
Fig. 4.

appears to take form as follows: We consider only the atoms taking part in the reaction, only the molecules which actually undergo the changes, and these only in respect to the proportions made use of, not in actual amounts of gas reacting nor in respect to the number of molecules concerned in the reaction.

Beginning with carbon and water, we have, first of all, this reaction: $C_2 + 2H_2O = 2CO + 2H_2$, the fundamental reaction of many processes in gas chemistry as well as in metal working, in making gas as well as smelting iron. One volume of carbon vapor has united with two volumes of watery vapor, steam, to produce two volumes of carbonic oxide and two of hydrogen, or we may imagine the equation on the gram-atom basis, and say 24 grams of carbon have united with 36 grams of water to make 56 grams of carbonic oxide and 4 grams of hydrogen gas.

This process continues as long as there is any watery vapor to react on the carbon, and the increase in volume from the reaction is very perceptible if the reaction is long continued. The next reaction is far more intricate, but also more important in the premises: $4CH_4 = C_2H_6 + C_2H_4 + 3H_2$. This tells us that 4 molecular volumes of methane, when sufficiently heated in the presence of hot carbon, react together to give 1 volume of ethylene, 1 of ethane and 3 of hydrogen; or, making use of the gram-atom values, 64 grams of methane have given place to 6 grams of hydrogen, 30 grams of ethane and 28 grams of ethylene. It is probable that in all these changes, and in a very great number of others like them, the carbon in some way acts as an excitant, a producer of molecular disorder.

No one can pretend to say why the change begins in this manner. No one of us can tell why the decomposition should not be followed by the conversion of all the atoms concerned in the reaction into ethylene, or all into ethane, or, as it has been most happily termed, di-methane, without the formation of any other hydrocarbon. Nor can anyone say why it is that when the change has begun it fails to continue until all the methane has been changed into the relative forms; but it is not thus the change is destined to proceed. It seems almost as if the loosened molecules had a kind of difficulty in forming satisfactory unions, for by gradually extending the heated space in the tube, and at the same time making the gas to pass very slowly, more and more complicated molecules are gradually built up. When this process of formation begins *de novo* the new formed molecules are always found to be members in the two series which have been indicated above, either in the series $C_n H_{2n+2}$, or in that of $C_n H_{2n}$, in the series of methane or of ethylene; but while cases of the formation of new molecules occur in both series in nearly equal degree and at nearly equal rates, reckoned as new molecules per minute, there seems to be a great difference in what may be called the relative power of survival of the members of the two series of molecules, both as group series and as individual molecules; as it were, a difference in their abilities to withstand the struggle for existence in their special environment. In regard to the development both of individuals and series, certain facts have been observed which may be regarded as almost invariable, and from these facts a theorem has been devised usually spoken of as the law of their formation. This "law" may be formulated thus: Beginning with methane, we consider that the carbon atom is centrally placed with respect to the hydrogen atoms, and that these are so situate that their centers of gravity are all equidistant from the center of gravity of the molecule. We may imagine the plane of gyration to be parallel to the surface of the paper, in which case the constitutional formula would be written:



See Fig. 4.

Ethane, to which the name di-methane has been applied, may be considered as two methane molecules which have lost an H atom each and then have united. It is, therefore, a very simple formation as derived from methane. The equation of the reaction would be $2\,CH_4 = C_2H_6 + H_2$, or, if written glyphically, it would be written thus:

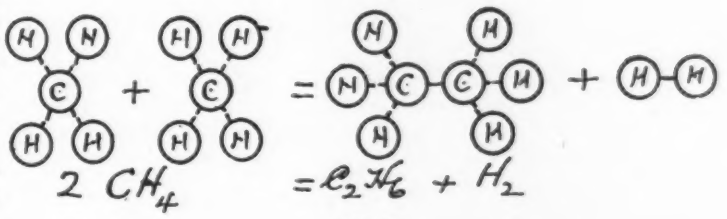


Fig. 5.

We can conceive this glyph as extended indefinitely in a horizontal direction, by supposing the H atom on the horizontal line to be dropped and another methane molecule added, which had already lost an H atom.

In this way are formed the glyphs with which the formulæ of the petroleum paraffines are found to agree; and when all has been said and done it is by no means unlikely that we would be justified in saying, and with which their molecular composition is found to agree, the list would be prolonged uselessly were all the possible items named, and while some of the hydrocarbons are well known to all, at least by name, others, it may be confidently said, are not even names. Methane, as every one knows, is "fire-damp" and "natural gas." The pentane, butane, hexane groups found in gasoline are series of isomeric hydrocarbons, and higher members still of the same series are found in the high test kerosenes and so on; more and more complicated molecules, with high and still higher boiling points, through the various paraffine oils to paraffine wax.

We may consider that the ethylene group is formed by complicated change from the methane nucleus, but in this case two hydrogen atoms are dropped, usually as symmetrical pairs, and not one by one, as asymmetrical individuals, and the link system called "the double bond" appears.

It is worth our while to remember that the higher members of the paraffine series, judging by reports of analysis, practically disappear in illuminating gas. After the second member ethane we find no more, and this one but infrequently. It must be remembered that no matter how much nor how many of the higher members of the methane series might be present in a specimen of gas, they would all be reckoned as methane in the at present most commonly employed of the analytical schemes. Nevertheless it seems to be a fact that the members of the ethylene series do take the places of the methane series; that is, the members of the series $C_n H_{2n}$ are found instead of the members of the series $C_n H_{2n+2}$.

As the amount of coke which is heated in the apparatus which has been described, attains to a red heat and still higher temperature, and thus in equal rate increases the amount of white hot coke which the gases meet in their passage along the tube, so does the amount of ethylene (C_2H_4) converted from the broken methane (CH_4) molecules by the action of the hot coke increase. Presently we find also propylene (C_3H_6) the second olefine, and then butylene (C_4H_8), the third. It is worth noting that just as all the paraffines are, by the ordinary text books which teach the course of analysis lumped as methane (CH_4), so all the olefines are commonly lumped, as ethylene, as if the writers of such text books were convinced either that the task of separating the individual gases in each group would be too much for the industry or the understanding of their intended readers, the chemists in the gas business. Propylene (C_3H_6), is usually reckoned as a true gas, since it functions as such at 760° mm. and 0° C., and as such is usually found in all coal gas samples, but not so all three butylenes (C_4H_8) for there are three of them, with the same chemical, but very different physical characters. Amylenes (C_5H_{10})—five of these are known—will sometimes be found, if they be looked for, and the two low boiling hexylenes (C_6H_{12}) the isomeres of that remarkable substance and important gas ingredient cyclo-hexane. This latter, almost never reported and seldom identified if found, is probably the ignis fatuus, the fatal fire, by which the transition to benzene is made at a high temperature. These important substances are almost never mentioned in

books of instruction in the art of gas analysis, and if one questions the writers of these books for the reason why of the omissions he gets for answer:

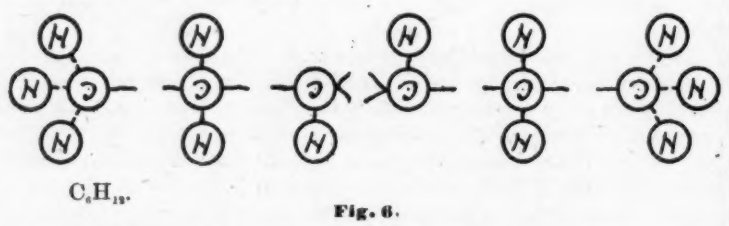
"It takes too much trouble to make such analysis and too much time to figure them out."

Unfortunately this is not sarcasm (would it were), but the words of a man who has thrown all the influence he has, and it is much, against the increase of information among gas men concerning the chemistry of their product.

The transitional character of cyclo hexane has been mentioned previously. It seems to indicate the path by which the olefines, or it may be the paraffines themselves, pass into benzene and higher compounds. It is not my intention at this time to follow this path out step by step, but only to indicate certain facts as rapidly as possible.

The olefines form a group by themselves just as the paraffines do, and in each new change of form n groups of the lower member are converted into n — 1 groups of a higher, if the changes take place within the series, and not by dropping hydrogen atoms from a paraffine.

When hexylene (C_6H_{12}) appears a remarkable transition comes with it. There is no real break in the chains, only an unexplained transition, yet the apparent break is complete.



C_6H_{12}.

Fig. 6.

Starting with an unquestionable paraffine, methane (CH_4), without any other manipulation than the passage of the gas over hot carbons, the entire series can, if time and patience are forthcoming, be built up. The conversion is only partial in amount in any experiment series because of the time limit put to it by human patience and physical endurance; but however deficient quantitatively, it is a perfect success qualitatively up to this point, to the appearance of hexylene in a relatively large quantity.

Sometimes it appears that other paraffines than di-methane, ethane (C_2H_6), are noticed even as early as at the end of the first quarter hour, but benzene sometimes appears quite as early as the first named paraffine, and a gas which was first supposed to be hexylene (C_6H_{12}) has been found before less complicated members in the chain. Consideration of such circumstances makes one to raise the question: "Is it hexylene?" And further study of the problem seems to suggest another explanation of a series of apparent contradictions, which are certainly not easily reconciled or explained.

As I have said before, if the experiment should stop short at hexylene this development would be orderly. We can easily and accurately explain every step in the chain, but if we persist in our experiment of passing the gas back and forth over the hot coke something happens for which no sufficient explanation has yet been given. Benzol, a member of another class of hydrocarbons, a ring and not a chain, as all so far have been supposed to be, appears; and following on this, naphthaline and then anthracene.

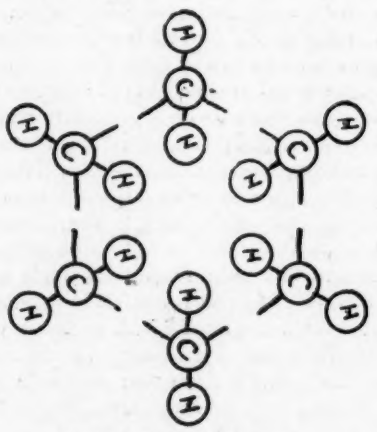
It is hardly a figure of speech to say that when one who is thoughtfully inclined to demand a reason for all he sees becomes for the first time fully conscious of the tremendous consequences dependent upon the seemingly trivial acts and processes of this experiment, he in truth is astonished, and thinks, if he does not say: "From whence are these?" Presumably from cyclo-hexane, and this is rendered more probable by the invariable appearance of large volumes of hydrogen at the same time with the benzol, which volume of hydrogen would surely appear were this the mode of transition, but which no hypothesis, no matter how ingenious, can logically account for on any other theory, unless the offered theory will also make explanation of the thermo-dynamic curve. We may consider normal or ortho-glyphtic hexane to be represented by a chain of 6 carbon atoms in a horizontal row, 4 of which are joined to 2 atoms of carbon and 2 atoms of hydrogen each, while the other two, the first and the last, are joined to only 1 carbon atom and 3 hydrogen atoms. At either end of the atom chain which constitutes the molecule is a single hydrogen atom, either of which removed permits the addition of new groups at the end it guards.

The high school theory of the formation of the ethylene series from the series of the paraffines presents theoretical difficulties nearly insurmountable, on account of the double bond. But if, as has been suggested in this paper, we abandon these puerile attempts to step on every figure of the carpet, if we content ourselves with saying that all the hydrocarbons are formed by additive rearrangement in independent series sometimes, and they do not always exist even as interdependent series (although, principally because it is so difficult to prove the contrary, it has been permitted to certain writers to maintain unchallenged the unproven hypothesis that the higher members of the ethylene series are formed from the lower instead of from the corresponding paraffines), yet the time is coming when this question of the point and method of origin will be so important practically that no doubt can be longer tolerated, and then we who are in the minority will have our hearing.

Two molecules of marsh gas become one each of ethylene and hydrogen by the two carbon atoms letting go two pairs of hydrogen atoms, one pair each, presumably H_2 and H_2. The interior atoms, as they are sometimes called, and the carbon atoms might be supposed to take a firmer hold on each other, to use a figurative expression.

If we accept the theory that all the four valences of carbon are equal this is simply inexplicable. It can no more be explained on this basis than the substitution of other monovaliants for hydrogen in methane; but if we admit a distinct "polarity" in all atoms this difficulty is out of the way once and forever, and we have two explanations, either that the hydrogen atoms of the same polarity, so to say, are dropped from both molecules, or the hydrogen atoms of the opposite polarity, and there is much reason for accepting this as true. This hypothesis, of course, supposes the existence of two kinds of atoms, one "dextro-type" and the other "sinistro-type." On this theory all the free gas molecules, as the oxygen in the air, will consist of two atoms of opposite name. The existence of the two atoms has been long known. The claim for distinct polarity is relatively recent in its formation, but it explains *why* a certain condition exists, which explanation has hitherto been wanting, and incidentally this theory gives the explanation of the change from methane to ethylene, from this same methane, as well as from other paraffines, to various ethylenes and other hydrocarbons, one after another, until cyclo-hexane makes its appearance, for a moment, to give place by dropping hydrogen to benzene, and the first hydrocarbon series is complete.

If six half ethylene molecules or six methane molecules partially disturbed, mutually attracting each other, approached towards their common gravity center it is plain that the union which they would probably form would be a ring-shaped molecule, in form such a molecule as cyclo-hexane is and with all its bonds equally strained. In other words, a molecule in the form of a closed circle would appear, and such a molecule certainly exists in cyclo-hexane, and this would convert into benzene, by the simple process of letting slip six hydrogen atoms, the interior six to unite as three pairs of atoms, as the molecules $3H_2$, and it has been shown again and again that the hydrogen formed into molecules just corresponds with this theory, as does the disappearance of the methane and the appearance of the benzene.



Molecule Cyclo-hexane.

Fig. 7.

Now, please consider what deduction may be drawn from the experiment I have spent so much time in describing, and about which I have said so many words. Let me name the facts brought out as rapidly as may be: 1st, as soon as the carbon has attained to a red heat for the space of an inch or so in the tube, so that the passing methane began to be heated red hot by contact, ethylene began to appear in the gas volume, the amount increasing with each passage of the gas over the hot coke; 2d, as more of the carbon was heated the rate of formation of ethylene increased in equal measure and some small part of the new

formed ethylene went to form higher members of the series by simple addition, or rather the higher members appeared and the rate of the appearance suggested this method of origin; 3d, the bulk of these higher members was indefinite and never large, and their relation to the ethylene series could not be stated except by analysis; 4th, when a large part of the carbon in the tube was red hot, so that its action on the methane and other gases was very powerful, a new phenomenon appeared, as it were, suddenly—benzol was formed; and 5th, in some instance when the experiment was prolonged naphthaline was proved to be present in large quantity, and always in small quantity when the experiment was continued sufficiently long to demonstrate the benzene positively.

This history may be regarded as that of the formation of the hydrocarbons by synthesis, and we must regard it as one of the ways, and possibly as the way, or as the most likely way, in which all of them were formed at first "in the beginning," in nature.

Two other methods of origin for the various ingredients of an illuminating gas must be considered as active during the process of gas making. We must admit this. Basing the admission on experience we have heard of what sometimes happens when we are distilling a cannel coal, or any gas coal for that matter. Under such circumstances we find that sometimes, perhaps frequently, large amounts of all these series of hydrocarbons exist in the coal stored up by occlusion. They are part of the mass as the water is part of a crystal, or as water is an essential part of a piece of sugar candy. They are present for liberation, and when heat is applied they are freed from their bondage and are able to functionate independently. But while the amounts thus liberated are large, and practically represent the whole of the gas obtained at a low red heat, they do not by any means represent the total yield. This is shown by the way in which the preformed oils distil over from time to time, as the coal is heated in a laboratory experiment. At the same time one is convinced that certain of the hydrocarbons are so intimately associated with the coal that only the very highest temperatures will liberate them, and that these complicated molecules are not infrequently broken up into the simplest forms before they are shaken free from the carbon which holds them. Here also we learn that this separation is only temporary, atoms, groups of atoms, sometimes whole molecules, once and again uniting to produce unexpected compounds.

This possibility of formation of naphthaline from the higher polymeres is important, and forms another and distinct origin for the naphthaline in the coal gas, since under the long continued influence of great heat, obtained at an expenditure of fuel perhaps unwise, the members of the naphthaline group of higher boiling point are "cracked." In other words their molecules are broken up, yielding acetylene for use as an illuminant and much naphthaline. The constitution of these hydrocarbons is interesting as are also their physical properties. In number they are three, one anthracene and two phenanthrenes, a dextro-type and a sinistro-type molecular form, which pair of true isomeres probably, for a wonder, present no known physical unlikeness, probably because we are insufficiently acquainted with them. Their boiling point is high, so high that it is set down simply as "above 351° C." in the case of anthracene, and they are, therefore, still fluid at a temperature under whose influence naphthaline is already a gas. Since the members of this group must be considered together the formulæ and relations are stated as below. Naphthaline distils between 180° and 200° C. scale, anthracene comes over between 340° and 360°, and phenanthrene accompanies it. Therefore the thermometric distance between naphthaline and these two oils is greater by one-half than the distance between ice and steam.

The benzol formula has been discussed together with the symbol used to indicate it, and the relations were shown by which the naphthaline fetter is established and maintained. The two formulæ which follow those of this isomeric trio must also be looked upon as, like naphthaline, derived from the benzol ring. In naphthaline a dextro-type and sinistro-type benzol ring are combined, so that a V.-VI. union exists, as shown in the diagram. In anthracene an acetylene molecule apparently is joined to two benzol rings, one dextro-type and one sinistro-type, the acetylene molecule coming in between and functionating as the link connecting them. The result is the same as if 7 molecules of acetylene had combined.

In phenanthracene an exactly similar series of molecules is engaged, but in this case the no longer central, but eccentric, acetylene molecule joins itself to a pair of dextro-type rings already connected by a union between C_6 and C_{11}, almost an unique linking. A sinistro-type form also exists which agrees with this in all respects, so far as known—should a difference between them be discovered it will be interesting indeed — but the principal practical usefulness of such a demonstrated difference would be to quiet the discussion in regard to the fact of the existence of both forms. Then the fact of their existence will be no longer open to the "doubts" of certain men, and the reputations maintained by wise objections will not count for so much. It is to these two oils that the solution of the naphthaline was once due. When pure they are solids at the boiling point of water; anthracene melting at 213° C. higher by 13° C. above water's boiling point than this boiling point is above water's freezing point; but phenanthracene melts at a comparatively low temperature, 103° C., hence when mutually dissolving and dissolved and in solution of and with other hydrocarbons they are nearer to ordinary experience. Commercially these oils contain both of the $C_{14}H_{10}$ isomeres; also some naphthaline and benzol, and it may be even lighter ingredients still.

The relationship between these hydrocarbons is shown by the accompanying diagrams of the molecules in juxtaposition for the sake of comparison.

Fig. 8 is a right-handed benzene ring. Its mate, the left-handed ring, has been illustrated and described.

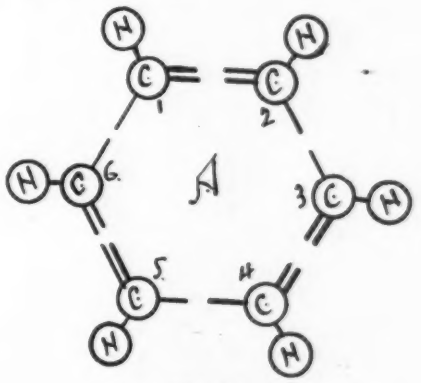


Fig. 8.

Fig. 9 is the pair of interlocked rings. The right handed benzene ring interlocked with a left handed benzene ring along the line of the double bond, the two rings having two less carbon atoms and four less hydrogen atoms after combination than before.

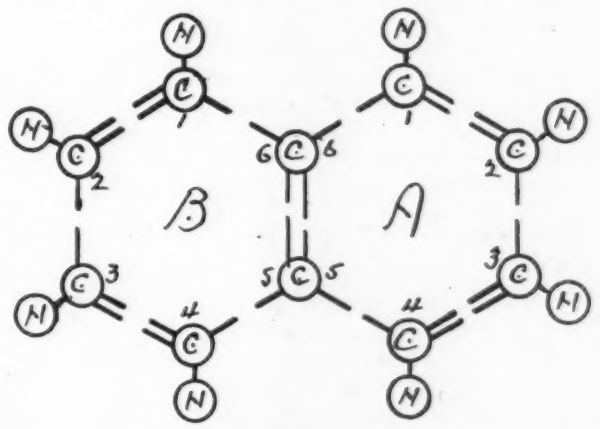


Fig. 9.

Fig. 10 is the classic representation of the "anthracene" molecule.

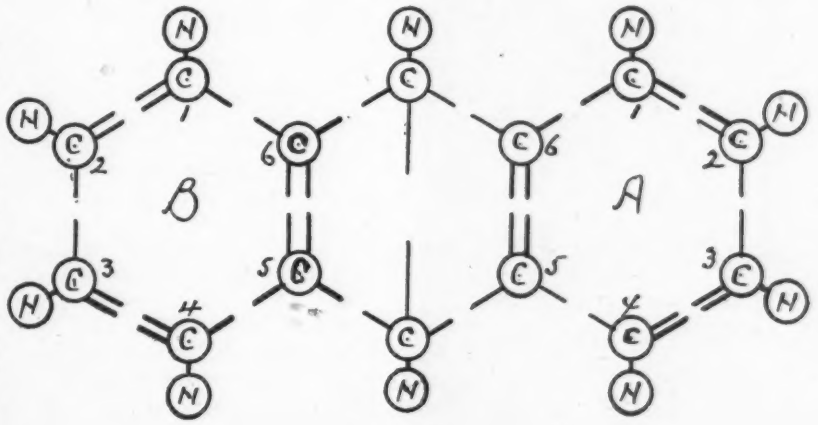


Fig. 10.

The name is derived from a Greek word meaning "black." This molecule is formed in exactly the way theory indicates it should be. Two molecules of benzol in the process of combination to naphthaline have begun disintegration, have dropped H_5 and H_6 from both rings. At this point an acetylene molecule has entered the combination, one of the links of carbon atom (a), uniting with carbon atom A_1, the other with B_2, while the third link joins carbon atom (a) to its corresponding hydrogen atom, and the fourth union is with carbon atom (b), as shown. The linkages of carbon (b) are understood to be in the same relative order. The triple bond between the two carbons of the acetylene molcules are thus reduced to one, the others satisfying the affinities of the benzene rings in places in which hydrogen has bren dropped.

This is the diagram which represents the most usually accepted view

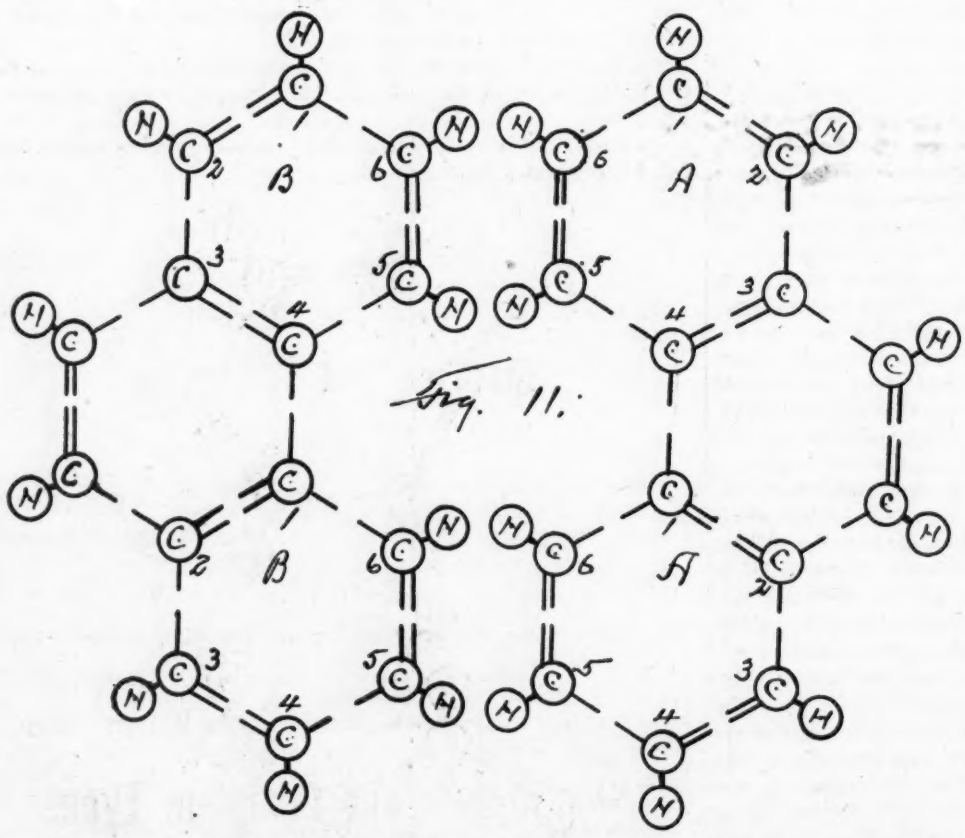


Fig. 11.

in reference to the constitution and various relations of the two phenanthrenes. It will be noted at a glance that these two glyphs, one representing a right-handed molecule and the other a left-handed one, differ radically from any others yet in question. It will be noted that the two rings are forms of the same name, that both are right handed or both are left handed. One also notes at a glance that these two rings are directly bound by the external valence of C_4 in the superior group uniting with the external valence of C_1 in the lower group; also, that the acetylene molecule has now only centrifugal relations. It is not in this system the central molecule, as it were the nucleus of the system, but it is excentric and distinctly asymmetrical. It is also to be noted that there is double linkage between the carbon atoms of the added group, the so-called "acetylene subsidiary molecule," instead of a single linkage only, as in anthracene.

It is worthy of note that while both of these forms, anthracene and phenanthrene, are produced by acting on the vapor of benzol with acetylene gas in the presence of hot carbon, the probable use of such carbon being to maintain the temperature of the reacting gases, when decomposition of the molecule takes place the resulting gases are not benzol and acetylene, but in the case of anthracene are di-methane, $C_2 H_4$, ethane and almost useless (to the gas works manager) paraffine, and the quite unwished for naphthaline; while if phenanthrene is broken up the product is naphthaline, the far more useful ethylene $C_2 H_4$ the first olefine.

(If the audience will permit I wish here to substitute demonstration and exhibition, during the next few minutes, in the place of description.)

We have, I think, considered the chemistry of the substances obtained from coal by distillation sufficiently to make understandable at least the proposition which I propose myself to formulate in the balance of this paper. We know that if the retorts are worked at a certain temperature (A), the naphthaline is not a nuisance, but if they are worked at a higher temperature (B), the naphthaline is a nuisance. These facts are capable of easy demonstration. The difficulty in the situation is found in the following: The gas maker insists that he must have the use of the higher temperature, since without it he cannot make gas with economy, either in quantity or quality. Granted that this assumption of the gas maker (it is really nothing but an assumption except in relation to one system of working) is true in fact, then from his standpoint the production of the naphthaline nuisance, as a chemical and mechanical condition in practice, is inevitable. What has been done to make it so?

The only change apparent in the chemico-mechanical scheme on which the gas making apparatus is worked, except the inevitable change in the raw material from time to time by supply-exhaustion, is the change in the temperature gradient and routine of changes according to which the retorts are worked, yet this change stands for a more or less complete destruction of the various olefines and paraffines, the poly acetylene also it may be, finally the anthracene and phenanthrene molecules, and the formation and precipitation of naphthaline. Investigation seems to show that the result of the present temperature schemes and their application in the retorts are just what we would expect to find under the conditions specified. The net result of it all is the "cracking" and destruction of the solvents, the anthracene and phenanthracene molecules.

This secondary formation of naphthaline is the result of the ordinary manipulation procedure in the gas works, just as it is the result of this system of manipulation and order of process in the laboratory. Given the conditions of the experiments, the results in the small laboratory do but typify the results which follow in the large one. The results in both are alike in all essential points of sequence, apparent cause, and secondary results, differing only in the scale on which the experiment is made, in the size of the working.

To test the theory just outlined, experiments were made with all due care in an apparatus which I think may justly be called a miniature gas plant. The details of some parts are shown in the diagrams. The idea held constantly in view in the design of the apparatus is, not to save the gas alone but to save everything which is obtainable from the coal, and to save this everything in such way and form that it may be examined at leisure, and thus not only may the various substances produced be definitely determined and their grouping studied, but also we may learn what will happen when changes are made in the details of the treatment, in the temperatures used and the grouping of the various products.

The coal is distilled in the retort (A), and from the very orifice, from the very point at which the retort ends and the secondary apparatus begins, the products of distillation may be either parted into groups, or individual products may be separated, or all may be allowed to go on together. Thus, at a selected point the tar and gas may part, the tar descending to the tar well by gravity, or by pumping in one of the many ways, while the gas, tar free, goes to the condenser and thence to the purification apparatus. Owing to the length of the condenser the temperature of the gas can be lowered to that of melting ice, to the Centigrade zero, which causes all ingredients which are "condensible matters" to change their physical form at a rate as rapid as that at which they give up their heat, those which become solid fixing themselves on the walls of the various condenser tubes to be removed in due season, the liquids flowing into the receptacle provided for them, the true gases saturated with the vapors of various liquid hydrocarbons going on to the holder reserved for retaining them,

As an alternative process the oils and the like could be sent into the secondary furnace where they would undergo decomposition in contact with white hot coke without mingling with the true gases, and leaving this tubular furnace they could be sent through a condenser at any chosen temperature, or the gases, vapors and fluids might be parted from many others as those just mentioned were.

In such processes as gas making, separation and recovery are at all times more or less collateral terms, because the second practically implies the first. Still another alternative is possible, both oils and gases

can be sent through the hot tube, through the heated tubular reaction chamber, so that they may, if they will, react on each other while at a very high temperature, and thus the result of their interaction may be noted. As an alternative to immediate separation the gases and oils may be permitted to remain in contact and to react on one another for an indefinite period. The investigation of a coal supply with such an apparatus requires us to make gas from samples of such supply in not less than three, and it may be in 12 different ways, and such investigation also implies an analysis of the gas and of the tar of the most searching and rigorous order.

Let me say in passing that since this question of the naphthaline nuisance was brought to my attention, now some years ago, I have studied at my leisure, and with as much care as I am able to use, more than 20 samples—to be accurate, 26—of coals, using in the study the very best apparatus and ample time. The advisability of publishing some of the results obtained was repeatedly suggested, but as the matter seemed one of academic interest and of no practical value no publication has been made or even planned for; but considering the problem in relation to naphthaline alone it may be that some few of the many observations made might have a practical bearing on the matter in hand.

In the first place I wish to take up the subject of the amount of naphthaline in the various coals, without applying such investigation to this question, to the discussion of naphthaline in illuminating gas, but simply as a matter in science, in chemistry at large.

When your President sent me the invitation to address you he laid stress on the discussion of the influence of the coal, as a part of the suggested scheme of my paper; that is, he specified the influence of the coal used upon the naphthaline production as a topic, as one of the points he thought should be discussed. It was with some surprise that I read the sentence, for wide as I knew your President's acquaintance with what I may call the laboratory side of the gas maker's art to be, I did not know that he had, even at any time, considered this part of the subject, which almost always escapes the lucubrations of the practical man.

I do not intend to say that the practical are not fully awake to the influence of the coal used upon the production of the naphthaline nuisance, for they cannot but recognize the fact that when they are using some coals there are troubles, and when using other coals there are not, but that instead of saying we will not use this coal on account of its naphthaline, they object, not refuse, and then abandon the objection, where the coal company gives them a discount, only to complain when the naphthaline asserts itself, as it surely will in time.

The fact of the matter is that the influence of the selection of coal is not the least of the possible factors having influence on this problem. It is not a negligible quantity; it is very far indeed therefrom. It is not my intention to name any special brands, the product of any individual mines, nor to be very explicit in statement, because by so doing I might do a serious injustice both to my hearers and to the coal dealers, who are absent, and also because the coal supplies with which I would be dealing are those of bygone time, of last year, or the years before that; not with those of next year which now interest us; and besides, the certain, if gradual yet constant changes in the quality of the coal mined insure that the supply of to-day cannot be judged by that of last year, nor that of the future by the present. Understand me, therefore, to be speaking wholly of last year and not of the hour.

For the purpose of the discussion which we have in hand we may divide all coals containing sufficient volatile hydrocarbons to be of practical use in gas making to rank them as gas coals, into three groups: (A), those which contain an excess of solvents; (B), those in which the naphthaline and the solvents are to all intents and purposes in an almost exact balance, as if the solvent substance had been saturated with the substance dissolved; and (C), those in which there is an appreciable excess of naphthaline to start out with. It may be urged that I am anticipating my discussion by thus speaking of the "naphthaline solvents;" but in the present state of the art, and of the naphthaline discussion in societies and in print, especially in the periodicals devoted to our interests, it can surely be forgiven me if I assume that an audience of specialists is familiar with circumstances and arts germane to, even if not directly connected with, their proper profession, their daily business. In a coal in which the solvents are in large excess a great part of the solvent oils can be broken up and still leave enough to keep the naphthaline in solution, the nuisance in hand, most surely, of course, if attention is given to the important question of proper working temperatures; but when the oils are saturated at the very outstart the least disturbance of the balance will simply overwhelm the works with the surplusage of the naphthaline, and this is just the result attained when the oils are broken up in practice.

At the same time it must not be supposed that a coal supply of say 20 car load lots can be so sampled that an assay of say 5 pounds can be trusted to determine the amount of naphthaline and its relations out of hand. To illustrate this: In March, 1898, a sample of coal was sent to me containing 5 distinct layers. The pieces were large, the four sent weighing fully 50 pounds, and they seemed to represent the entire thickness of a vein. Four of these layers were perfectly distinct and entire; the fifth was very much crushed and broken, showing that it disintegrated much more rapidly than the others, so that it would afford practically all the "crumbs and sweepings," and in a clean-up these would furnish more than their just proportion of the charge. It suffices to say that the layer containing the most naphthaline exceeded the average by 30 per cent., while the one containing the least fell 28.3 per cent. below the average. So, then, a charge made up largely from the dust and crushed coal from the floor of the shed would have given no trouble, while a charge made from pieces selected for their fine appearance would have made so much naphthaline that, if the management were taken by surprise, it might well have been overwhelmed. In another case the average of 10 samples of 5 pounds each, taken from the coal used in 1900, contained only 60 per cent. as much naphthaline as did an exactly like sample from the coal used in 1902, but the 1902 sample contained so much solvent oils that there was no naphthaline trouble during its use, while complaints were constant two years before. This strange (for with our present meager data it is not to be accounted for) variation explains why some men regard naphthaline as something without known laws, and almost as an "evil-jin." Others declare it a bugbear, and others again will name it a nightmare.

In some cases naphthaline seems to hold such relation to its solvents that it may play the very mischief with the peace of mind of the works' manager, because it may appear anywhere in the distribution system at any moment. Twice I have written letters to the managers of gas works asking for definite information about this nuisance, only to receive in reply their positive assurance that the naphthaline problem really had no existence except in the superheated imaginations of inexperienced men, yet in both instances I had from them later on coal samples and requests for any information I could give in relation to the naphthaline nuisance. By reason of these facts, and from the consideration of other like data and information items, it seems to me perfectly absurd to say, as so many do, that all the difficulty in magaging this ever present phantom, which all fear as threatening if not actually busy in the pipes, is due to the incompetency of the gas works' management. Such explanation is absurd; such implication is a slander against which the rest of us have a right to protest.

As specialists trained in the practical work of their art the American gas men are as competent, as ready, as forehanded, as are the chemists engaged in any other industrial occupation in the whole, wide world. That proposition I am ready to maintain anywhere against all comers, but I do not think that the gas works' managers call to their aid nearly so much as they might the skill of those who stand ready to aid them with head and with hands, by the use of technical skill spent on examination and selection of the best raw material. It is not so very difficult a matter to tell from a fair sample what the experience of the user of any given coal is likely to be in regard to this troublesome intruder. If all precautions are neglected and multitudes of loopholes are left unguarded, not loopholes alone but windows and doors as well, to give access to the mischief making demon, there is no use in supine fatalism in regard to this question, and it is not good sense to yield to the "nothing can be done" notion until the art of the chemist has been at least tried. I do not think that a manager should assume that he has done his whole duty in the premises until he knows all that the science and art of the chemist can tell him, and I think, were I a buyer of coal, that I should insist on a tender by sample, have this sample assayed, not for sulphur only, but for about 26 other things, and I should insist on the samples being up to grade in all respects; and finally I should insist on the coal being up to the sample. The coal dealers, at least those I have met, will all bear watching. They deserve suspicion quite as much as the much abused gas men, and I know of at least one instance in which I have the best of reasons for saying that a very inferior coal was delivered but not paid for at the high price and in place of the excellent coal which I had examined. In this case an inferior coal was delivered in place of a very high grade sample. It must be a most unsatisfactory place indeed to be in, that of the gas works' manager who buys a coal by the run of the mine. On the strength of the reputation it has obtained from one vein, it may be a mile away from the place from which his present supply comes and even from another horizon, when he finds the raw material very inferior, his coal sheds full of coal, for which his company has already

paid the highest price and his customers dissatisfied with the inferior quality of the gas, into which he must mix a costly enricher to make its grade, when the true cause of all his woes is a gold brick purchased because of another's better fortune. So much for the influence of the coal.

To return to the miniature plant. With it were made experiments leading gradually to the following results, in discussing which I shall speak as if they had been made in a continuous series upon a single piece of coal. In point of fact a number of partial experiments are here assembled, and in the account which follows I am giving, not the account of an experiment written out by the observer as detail after detail is seen, or as if taken down in shorthand as the results gotten are observed, but I am giving the impression concrete in my mind from the careful and systematic comparisons of results from various specimens, yet as far as possible I have isolated the deduction from the supporting premises, and I am very confident that anyone hereafter experimenting along the same lines will reach like results.

At the same time I wish to mark one point as a reservation. One conclusion which I reached will be noticed as widely different from that said to have been carried into practice on a large scale, and with huge success by certain gas engineers in England. It is beyond my intention to question their success, or to suggest that they attained it in any other manner than that in which they say they did, but I doubt if using the ordinary coal of daily trial in this country they would have attained any such gratifying results.

In my experiments the retort was sometimes heated very slowly, sometimes very rapidly, but always most carefully, to ascertain for certain if rapidity of heating made any difference in the practical results. When the products of distillation were sent to the condenser directly it was not to be perceived that there was any difference in results, excepting that when the evolution of gas and tar was rapid the rapid rise of temperature which accompanied, or rather caused it, led to the naphthaline going in greater quantity to the gas than it was accustomed to go when the heating was less violent and prolonged. The result of the average slow experiment was to send the tar towards the well with all the naphthaline, while in an average rapid experiment, one with a higher temperature, the napthaline in some part would reach the condenser. By means of experiments of this sort, some made slowly, some more rapidly, in which the temperature of the retort was raised as fast as possible, the charge of coal being in every case weighed accurately and in powder which had passed a 10-mesh sieve, it was determined that the amount of the products from a given weight of coal of a given sort was practically a constant, and that the products were as nearly constant in character. It was also determined that the variation, such as it was, was due to the vapors and gases undergoing molecular change under the influence of the hot carbon of the charge, and that by using suitable means to get the gases away from this influence suitable precautions reduced these changes practically to zero. I believe from my experience in these inquiries we are justified in saying that the products of the distillation of any given coal are constant in quantity and quality, if they are not subjected to later and secondary influences, which practically amount to redistillation.

Having satisfied myself of this fact by a preliminary investigation I obtained a relatively large amount of coal, had it ground and sifted, dried for 24 hours by exposure to the air in a steam heated room, and packed in air-tight containers. A sample of this coal was distilled and the fluid and gaseous fractions parted immediately at the mouth of the retort. The gaseous fraction was passed into a condenser with brine at a temperature 2° or 3° below zero, thus taking out the solid and fluid hydrocarbons of low boiling point and passing on the true gases, which went to a holder over mercury, while the fluid portions were trapped at the bottom of the condenser. It may be stated in passing that the condenser through which the tar passed was heated by a superheated solution; thus the tar was kept in a fluid state until it reached the well.

This result was regarded as representing a normal distribution of ingredients, both in respect of place and time required for evolution. When the temperature of the charge was only just sufficient to attain continuous and complete liberation of all the volatile contents of the coal and exact analysis determined the amount of each ingredient. In this distribution all of the naphthaline and more of the benzol than was expected were found in the tar. In the condenser of the gas system a few naphthaline crystals were found, which came seemingly from the last few liters of gas which passed through the condensers, but the amount was insignificant. When the retort was heated to the highest useful temperature as rapidly as possible some of the naphthaline was disengaged from the oil and was caught in the condenser tube, but its melting point was not so changed by association with the benzol as by some theories it should have been, for the two parted very early, the naphthaline becoming solid in the tube and the benzol going over into the well. The average of these two sets of experiments was assumed to represent the normal distribution of the products of the distillation of coal, when the products of such distillation are freed at once from the influence of hot carbon and all interaction between the true gases and vapors and the tar is prevented. No doubt my surprise that almost all of the naphthaline should have remained with the tar oils, even when heated above its boiling point, or have been reabsorbed so quickly, will be shared. It cannot be explained, unless we assume that the vapors are also mutual solvents, an hypothesis I do not care to discuss. I only note that the facts are as stated. If this is the normal relation of the distillation products under these conditions, they are certainly very greatly changed by permitting both the gases and vapors to pass in company through a condenser heated to 105° C., under which condition all of the naphthaline and 92 per cent. of the benzol were taken out of the gas by the tar oils, while all the light hydrocarbons and some with boiling points much higher than the temperature of the experiment were carried through the chilled condenser to be taken out in a condenser cooled to 3° C. This seems to me to show a tendency of the two groups, the paraffines and the olefines on the one side and the closed ring compounds on tbe other, to part company at about 100° C., the temperature of boiling water. This attraction among the individuals or power of mutual solution would tend to explain why the light paraffines do not aid in keeping naphthaline in the gas, when the solvent power of the benzol is satisfied; there being nothing else to hold it the naphthaline must fall. I thiuk this side of the question should be investigated with more attention than is usually given to it.

If, however, instead of passing the distillate through a condenser at 105° C., it is passed through a condenser surrounded by hot xylene as circulating fluid (boiling point 140° C.), the benzol is all removed from the tar coming out with the gases and vapors, from which all but about 2½ per cent. can be subsequently removed by cooling the gas in a condenser with a circulation at −3° C., while at −15° C. the condenser removes all the benzol. At the same time that the benzol thus escapes the solvent action of the tar oils the naphthaline remains with them, their hold is so much more powerful for naphthaline than that of the benzol. This experiment while interesting in itself is very suggestive of the rational treatment of the naphthaline nuisance in the gas works.

By cautiously raising the temperature of the condenser above 130° C., which can be done by using aniline (boiling point 183° C.) as the circulating fluid instead of xylene, a point less distinctly marked but near to 175° C. is noted, at which a very considerable quantity of naphthaline is present in the gaseous and vaporized portion of the distillate. The inherent interest of this fact is not lessened if the gases and vapors are then led through a series of condensers at lower and lower temperatures, which gradually cool the gas, the gaseous mixture produced by the previous processes. For, if the gradient is very steep, so that the gas is at once cooled say to 50° C., the naphthaline is thrown out in crystals almost entirely; but if the gas be very slowly cooled to the same temperature much of the naphthalene remains in it, as if some mutually solvent action were now exerted between it and the benzol.

In a number of instances the naphthaline remained in the gas until the temperature fell to the minimum, being deposited gradually little by little all the way through the tubes, but at other times, after having been carried down a descending gradient from 30° C. to 15° C., without any coming out, the entire naphthaline content would come down suddenly, so that it seemed to "fall like snow flakes" and blocked the pipes.

[To be Continued.]

Retort Oven Coke for Foundry Use.

[A paper read by Mr. W. J. Keep, of Detroit, at the last meeting of the American Foundrymen's Association.]

My excuse for saying a few words on this subject is that for a year and a half I have used retort oven coke exclusively, melting about 80 tons of iron per day. I have used coke made at three different plants, from Hamilton, O.; Sharon, Pa., and Detroit, Mich. This coke was made from a great variety of coals from West Virginia and Pennsylvania. The coke used during 1902 was made in Detroit, Mich., and was uniformly good. At times during January and February of this year we received some coke that was not satisfactory because the makers could not procure proper coal owing to transportation difficulties. When this condition changed the coke again became satisfactory and has continued to be so.

During these same early months of 1903 founders all over the country had trouble with coke made in beehive ovens. Founders in many parts of the country were obliged to take any kind of coke that

they could get in order to keep running. During the past season most of the best deposits of coking coal in the Connellsville region have been purchased by the United States Steel Corporation and very little genuine Connellsville coke is available for general foundry use.

It may be interesting to describe in a few words the old fashioned beehive oven and the newer retort oven. The beehive oven takes its name from its interior having the shape of the old dome shaped beehive. The size is generally from 8 to 12 feet in diameter and from 6 to 8 feet high. The coal is charged through a hole in the top and is spread evenly over the floor to a depth of 18 to 28 inches. There is as much space left over the coal for the burning of the gases as is occupied by the charge of coal. The brickwork of the oven being still hot from the heat of the previous charge soon causes the fresh charge to ignite and distill off the gases, which are burned in the dome above the coal. The heat being reflected downward causes the distillation to gradually proceed toward the bottom of the coal. When all the gas is driven off, which takes from 48 to 72 hours, the coke is quenched while yet in the oven.

The bright glistening surface of Connellsville coke is principally due to this quenching inside the oven and the columnar structure is due to the gas rising vertically as the coking proceeds downward. Blackheads are the lower portions of the charge that rest on the floor of the oven and which are not thoroughly coked.

The retort oven is a closed chamber from 15 to 24 inches in width, from 5 to 8 feet in height and from 25 to 45 feet in length. From 25 to 50 of these ovens are placed in a battery. The coal is charged through three or more openings in the top and leveled off to within a foot of the roof, after which the oven is carefully closed and sealed in order to exclude the air. The oven is heated by the combustion of a portion of the gas driven off in the process of coking. This is not burned in the oven itself, but is burned in flues constructed in the walls of the individual ovens. The heat is conducted through the walls of these combustion flues to the charge of coal and distillation thereof is started immediately. The gas which is driven off is conducted through a series of apparatus in which the tar and ammonia are recovered, after which a portion of the gas is returned to be burned in the oven flues and the balance is disposed of as local conditions determine.

Distillation proceeds from the side walls toward the middle of the oven and the gas is probably driven toward the center of the oven, where it rises, forming a cleavage plane the whole length of the oven. When the process is completed, which takes place in from 20 to 36 hours, depending upon the width of the oven and the temperature maintained, the whole charge is pushed out by a steam electric ram and is immediately quenched. The oven is at once closed a nd without any loss of heat from the oven itself is again charged with coal.

On account of the cleavage plane through the center of the charge no piece of coke can be longer than half the width of the oven. Owing to the complete exclusion of air th ere is no combustion in the oven, and as the temperature of the oven whe n the coal is charged is very high there is a considerable decomposition of volatile matter with consequent deposition of carbon upon the coking charge; as a result the yield of coke is a little higher than the theoretical yield as calculated from the analysis of the coal. Quenching the coke outside the ovens mars the appearance of the coke, somewhat destroying its bright silvery luster, but probably results in carrying off an appreciable quantity of sulphur.

It is evident from a comparison of these two methods that coke made from the same coal will have a slightly higher percentage of fixed carbon and a slightly lower percentage of ash if made in a retort oven.

The beehive oven is almost universally located at the mines from which it draws its supply of coal. Retort ovens are located in places that provide a market for the coke and gas. To allow a continuous operation of a retort oven plant the product must be sold as fast as made, and to do this a uniform quality of foundry coke must be maintained. The quality of retort oven coke depends upon the skill of the operator, upon the method of preparing the coal and more than all upon the quality of the coal used.

Our experience with retort oven coke began during the fall of 1901. We were at first induced to try one car, and when it arrived it was so black and in such small pieces and looked so badly that we refused to try it in a cupola, but the makers proposed to pay for all poor castings, and under these conditions we used it in the same proportion as the Stonega beehive coke that we had been using previously. The iron was very hot and satisfactory. We ordered 5 cars more and ordered retort oven coke from other ovens until we decided that the coke worked well in spite of its very bad appearance. From that time to this we have never had a pound of other coke. All through 1902 the coke was so uniform and satisfactory that we melted 9 pounds of iron with 1 pound of coke.

There is a great advantage in having a local retort oven coke plant, because it enables the founder to keep in close touch with the source of his supply. Owing to the necessity of having a laboratory at a retort oven plant to keep track of by-products the coke manufacturer keeps himself informed as to the chemical composition of his coal and coke and can make a very uniform product. Such local coke plant will have a very large variety of customers and therefore can supply the founder with a very uniform quality of coke because any inferior coke can be sold to domestic users or to manufacturers where it will do no harm. Experience has proved that with a retort oven satisfactory foundry coke can be made from coal that when coked in a beehive oven would be unfit for foundry use. This helps the founder in that it greatly widens the field from which he can draw his future supply of fuel. Retort ovens are at present being erected in various cities, and I understand that an 80-oven plant will be in operation in Milwaukee in a few months. This will be a great relief to the founders of this city.

Modern Manufacturing Methods.[1]

Some time ago we published an article pointing out that the equipment of a workshop with modern tools did not by any means guarantee that the process of manufacture would be economical. It is quite possible to spend thousands of pounds on capstan lathes and the like without finding any appreciable result when the profits are reckoned up at the end of the year. Indeed, calculation may show a distinct loss if the additional capital be brought into account, and due allowance be made for depreciation and antiquation of the new tools. It must be remembered that the more highly organized a machine is the greater is the risk that it will break down, or become superseded at an early date, and therefore the larger must be the percentage written off its value year by year. With such a tool as a 10-inch sliding lathe, for instance, the annual depreciation may be very small indeed. If used carefully and intelligently, and occasionally overhauled and set up, it will last almost indefinitely. It is almost impossible that the time should ever arrive that such a machine will not be needed; and even if the use for it in a particular works should cease, it will always have a second-hand value. But with a machine designed for producing a small range of special forms, with the utmost celerity, the case is quite different. Such a machine is usually costly in the first instance; it is liable to breakdowns of a serious nature, and, most important of all, it may be superseded by a more efficient tool long before it has been worn out. It follows, therefore, that a modern tool must turn out a lot of work if it is to earn a profit for its owner.

In the matter of labor it is generally economical enough; but the interest, depreciation, and antiquation account for a large weekly sum, and are not so vividly appreciated by managers and foremen as they are by an accountant. Modern machines demand modern methods of management, and without them they are doubtful investments. They add greatly to the responsibilities of manager and foremen, and unless these officials realize that all the thinking that was formerly done by the turner and other machine men now devolves upon them, and, further, that it most be of a more strenuous and foreseeing kind, the result will be disappointing. New tools can only be introduced satisfactorily into a shop in which modern methods have already taken root. As we explained in our previous article, the methods may be brought to a high state of efficiency in a shop in which all the machines are old. Naturally, in such a shop the practice will be different in detail from that which prevails in a shop in which all the apparatus is of the latest design; but in each case the principle will be the same, and therefore it is possible to introduce modern methods before any great expenditure has been made upon tools.

Of course, no change can be made without some outlay of money. The impecunious man cannot afford to be economical; he must use the means he has at hand, whether they be the most fitting or not. A man with only one suit must wear his best clothes all the time, whether he be paying a visit of ceremony or digging potatoes in his garden. But, nevertheless, very great changes can be made in the procedure of an old business in the direction of economy without the outlay of great sums. We do not mean that they are easy to make, or that it is a light matter to alter a system which has existed for years. On the contrary, it is a task of immense difficulty, and can only be accomplished by iron resolution, and by hard and persistent thinking and working. But a commencement can be made without serious additions to capital. Now the first essential of cheap manufacture is the

1. *Engineering*, London, England.

diminution of types and standards to the smallest number compatible with efficiency, and hence some of the earliest work needs to be done in the drawing office. In every engineering works of considerable age, and in many that are comparatively new, a few minutes' investigation of drawings would show that there are vast numbers of parts of machines which are practically alike without being identical. For instance, in engine works there will be glands for, say, ¾-inch spindles that differ in length, in external diameter, and in the distance from center to center of the stud holes. Some refer to slide valve spindles, some to stop valves, some to throttle valves, some to blow-off cocks, and what not. Evidently economical manufacture is impossible in a place in which small objects like glands have to be made in twos and threes, and in which it is impossible to carry a reasonable stock of any particlar kind. One knows by painful experience that if in such a place the manager be taken with a fit of economy, and stocks two or three sizes of such glands, the demand is pretty certain to run on the other sizes, and he has the annoyance of seeing his shelves filled with goods that are not wanted, and at the same time of having to execute a series of small orders under conditions that cannot show a decent profit.

Under such circumstances it seems natural to declare that one size of gland ought to be adopted for all spindles of a given size, and none others made, except for repair work. Nothing is more easy than for a manager to issue such an instruction; but modern manufacturing methods cannot be introduced by a stroke of the pen or a verbal order. They involve continuous hard work, and it is seldom that all this work can be put on to a subordinate. The motive power to effect alterations in established usages and designs has to be found by the owner or manager of the works; and it is just because he is sometimes lacking in the necessary strength that the attempt to introduce modern methods is so often a failure. Such an apparently simple matter as the standardization of one size of glands may mean a lot of trouble, for possibly a dozen patterns will have to be altered to admit of the change, and one alteration may sometimes involve several others. For instance, an increase in the diameter of the gland for the valve spindle of a steam engine may involve an alteration in the main bearing to permit of the eccentric being shifted sideways. It will be well if this be appreciated at the time the change be determined. If it should happen that it is only found out when the bed-plate or bearing has been cast and machined, one can understand that the manager will curse modern methods, and ask himself wherein the profit of them is to be found. It is quite certain that if such a change is put into the hands of a man who is adequately paid by $10 a week, there will be trouble in the shops.

Suppose, however, a score of such changes are in progress at the same time; that in addition to glands of various sizes there are spindles, studs, pins, brackets, bearings, governors, and a dozen other things being reduced to standards; evidently a most important change in the direction of the cheapening of manufacture is being made. Articles can be made in dozens and grosses that were formerly made in units and dozens; and even with old-fashioned machinery great economies can be effected. But the period of transition will be a weary time for the manager. He will have to supply the lack of brains and energy in a dozen subordinates, and oftentimes he will find himself greatly perplexed as to how far to go in the way of standardization. It may seem absurd to spend $250 in altering a design to save a few shillings in construction, but nevertheless the outlay may be cheap to secure uniformity and to eliminate chances of error. Each case needs to be considered on its merits, but as the object of modern methods is to reduce engineering construction to mere manufacturing, more outlay to secure standardization is justifiable than appears so at the first blush. The difference in labor cost between a gland that is made specially for a job and one that is part of a gross lot may not be very great, but to its labor cost must be added the expense of the care and thought necessary to get it made. The united efforts of draughtsmen, clerks, foremen, pattern keepers, and storekeepers are required to get that gland made, whereas if it had been of standard size it would have been in store, and an order sheet, written by a junior clerk, would have sufficed for its delivery. Modern methods of manufacture demand more and better foremen than the old system, because their essential principle is that the machine man shall not exercise any discretion at all. The foreman has now to think for every man beneath him, and therefore it is evident he must be relieved of all unnecessary distractions. An odd size of a gland makes as much demand on him as a basketful of the standard size; and if there be many odd sizes, an additional foreman may be needed in a shop, representing wages of $600 a year, or a capitalized value of $6,000 or $7,500.

The standardization of designs is an essential feature of modern methods, and it is not to be undertaken without expense. Unfortunately, there is nothing to show for the outlay, and it is difficult to persuade an accountant to permit the cost to be included as an asset in the balance sheet. He will put in a new lathe without any demur, but the alterations of drawings and patterns, which are required to render a new tool really valuable, do not raise any enthusiasm in the average bookkeeper. The only immaterial asset he knows is "goodwill," and experience has taught him to regard that with considerable suspicion. It is one of those things which disappear while you wait, and which bulk largest in the balance sheets of unsuccessful firms. But a good deal of the standardization of designs can be effected for the price of a couple of automatic machines, and the outlay will pay for itself very rapidly. Whether the shop be organized on a modern basis or not, economy must follow from the reduction of the number of diverse patterns, and if this be accompanied with good shop management, with high-cutting speeds, and with strenuous thought on the part of manager and foremen, it is quite possible to get results out of old machinery which cannot be attained with the latest mechanism when these features are absent. We repeat, and it cannot be too often reiterated, that no amount of expense will put a works on a paying basis unless with the new machinery there come new ideas, and those at the head of the concern realize that greater effort is demanded of them. In spite of the perfection of mechanism, which is the mark of the age, brains are still the most important part of the equipment of a works. Formerly every man was expected to be intelligent and thoughtful; now the mechanic is being displaced by the laborer, and the thought which he had to expend on his work has to be provided by the foreman. The difference is like that which exists between driving a horse and a motor car.

Many a man gets home because his horse knows the way; if he falls asleep or becomes involved in thought, the horse will take each turning safely. But with a motor car all is different; it has no volition, and all that it can be relied upon to do is to go straight on. Such a course must, of course, end in the ditch. The driver has to keep wide awake, and to guide the vehicle at all times. In the same way a modern manufacturing concern needs constant care and thought to keep it in a paying condition, and there is no hope of rest for those that direct its fortunes. Their car may be of the newest design, with the most powerful engines, but the greater the speed it is capable of, the greater is the care needed in keeping it on the road.

ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

MR. J. A. MCINTYRE, writing to us under date of the 13th inst., says: "The steamship 'Roselay,' which left New York early this month for various South African ports, took out what will be probably the first electric locomotive to enter the 'Dark Continent.' The locomotive, which was manufactured by the C. W. Hunt Company, of West New Brighton, S. I., is shipped to the order of the De Beers' Consolidated Mines, Ltd., the most powerful mining syndicate in South Africa, for use on one of its plants. The locomotive is of the latest storage battery type, standard throughout, with the exception of the gauge of the wheels, which is special to suit the track in use at the mines."

THE projectors of the gas plant for Berwick, Pa., say that work on the same will be completed by January 1st, 1904.

WORK on the reconstruction of the Cape Island Gas Company, of Cape May, N. J., is well underway.

MR. H. B. WHITE, Secretary of the Waterloo (Ia.) Gas and Electric Company, says that the damage to the plant, through the fire that occurred thereon some days ago, will not exceed $2,000. To judge from the original dispatches concerning the happening, one could scarce banish the belief that the plant was totally wrecked.

AT the annual meeting of the New Brunswick (N. J.) Gas Light Company the following officers were chosen: Directors, John C. Eisele, Nathaniel King, Halsey M. Barrett, R. W. Johnson, Willard P. Voorhees and J. Bayard Kirkpatrick; President, J. B. Kirkpatrick; Treasurer, John C. Eisele; Secretary, Halsey M. Barrett.

THE gas plant at Gilroy, Cal., is being operated on municipal account, and the operation thereof seems to center in the Gas Committee of the City Council. Not long ago complaint was made by a resident of the place to the Committee that he had to pay $12 per ton for coke, whereas the city was selling it in "large lots" to a San Jose dealer for $6.50 per ton. The complaint was "referred."

THE Excelsior Gas and Coke Company, of Topeka, Kas., recently handed to Mayor Bergundthal a check for $300, which sum was to be added to the fund that was being raised for the benefit of the sufferers from the floods that caused such suffering in certain sections of Topeka. The check was accompanied with a statement to the effect that the Company stood ready to increase the offering to $1,000, if such increase were deemed necessary by the Mayor and the Committee.

THE plant of the Spokane Falls (Wash.) Gas Light Company was sold at auction the 9th inst. to Mr. Charles S. Reeves, who represented the firm of Messrs. Cyrus Pierce & Co., of Philadelphia, who are the chief owners of the plant through share purchases made some time ago. The sale was for the purpose of clearing title. The sum bid for it was $408,000.

GOVERNOR BATES, of Massachusetts, has signed the bill authorizing the consolidation of the several Boston Gas Companies.

WISE ones say we may not look soon for a decline in the price of cast iron pipe.

MR. T. F. RUNNER, writing from Freeport, Ills., under date of the 15th inst., says: To the Editors AMERICAN GAS LIGHT JOURNAL—I have read Mr. Bullock's several communications referring to his experience with cement joints for street mains. Having used cement for joints with entire satisfaction for over 15 years, it may be of interest to others to know the details necessary to insure success. First, the soil must be of such a nature and the pipe thoroughly bedded on the bottom of the trench to insure against settliug that would cause strain on the joint. When the soil conditions are not right we use lead. Any slow setting Portland cement will do. We prefer the "Atlas" brand and use it without sand. In making the joint we first use yarn, the same as for lead, pounding it home hard. Any number of joints may be yarned ready for the cement. Enough cement is then mixed for one joint and the space in front of the first yarn thoroughly filled. We then use a second course of yarn, full as heavy as the first, using only the yarning at first to ram it back until well started; then the caulking hammer is used, lightly at first, being careful to drive the yarn uniformly, afterward pounding hard so that the water from the cement is forced out through the yarn. Your joint is now tight, and there will be no blowholes, even under 35-tenths gas pressure. The joint is then pointed up flush with the face of the bell. We prefer not to have the joint left with a bead. We never had a leaking joint when made in this way. Our very low leakage account of 3.2 per cent. on our make of gas for 1902 should be conclusive evidence that cement joints are successful in Freeport.

MR. JOHN C. D. CLARK, formerly in the service of the Peoples Gas Light and Coke Company, of Chicago, has accepted the position of Superintendent of the Bureau of New Business, Laclede Gas Light Company, of St. Louis. Mr. Clark was very successful in Chicago in the placing of Humphrey gas arcs, ranges and the like.

A CORRESPONDENT in Paterson, N. J., writing under date of the 15th inst., says: "I note your reference in the JOURNAL, dated to-day, respecting the officers in charge of the Paterson and Passaic (N. J.) division of the service of the Public Service Corporation, of New Jersey. The list given is in error, as the following from the Paterson *Guardian* of recent date will show: General Agent, Wm. H. Rogers; Agent for Passaic District, R. R. Young; Engineer of Gas Department, W. L. Williams; Superintendent of Works and Distribution, Gas Department, A. D. Whittaker; Superintendent of Electric Department, W. M. Buck; Asst. Superintendent, Gas and Electric Department, Passaic District, C. A. Stelling."

THE Greenfield (Ind.) Natural Gas Company has petitioned the City Council for the right to sell gas by meter at the uniform rate of 25 cents per 1,000 cubic feet.

THE Nashville (Tenn.) Gas Company has instituted a suit for damages in the sum of $25,000 against the local street railway company, the allegation being that its main and service pipes have been injured to at least the amount sued for by currents from the railway company's method of operating its system.

A CORRESPONDENT in Saginaw, Mich., forwards the following, under date of the 11th inst.: "At the East Saginaw Club recently was given a very entertaining dinner in honor of Messrs. A. G. Hodenpyl, New York; H. D. Walbridge, Detroit; Clarence M. Clark and Secretary G. L. Estabrook, Philadelphia, and M. S. Hopkins, Columbus. The hosts were George B. Morley, Thos. A. Harvey and B. C. Cobb. The gentlemen in whose honor the dinner was given are here inspecting the properties of the gas, electric and street railway interests of which they have recently acquired control. Those who were present from this city as guests were: J. B. Peter, W. S. Eddy, A. W. Field, H. T. Wickes, A. D. Eddy, G. M. Stark, Watts S. Humphrey, W. H. Wallace, John T. Winship, Otto Schupp, F. D. Ewen, W. J. Hunsaker, P. P. Crafts, F. H. Potter, George W. Morley, Charles A. Rust, Eugene McSweeney, W. B. Mershon, Charles S. Smith and George Grant. At the dinner the party was seated about a large round table, 15 feet in diameter, placed in the dining room of the Club. In the center of the table stood a huge bouquet of peonies, and radiating from the center were foliage and blossoms of the same. The menu comprised a full course dinner and was all that could be desired in selection, preparation and serving, doing honor to the hosts, the Club and Manager Farmer. Following the serving a period was spent in informal toasts, Thos. A. Harvey filling the roll of toastmaster capably and acceptably. During the talks given by the guests, the objects, aims and plans of the Company were set forth and the advantages and improvements which will accrue from the incorporation of the local companies under the one management were clearly explained. In response the Saginaw speakers welcomed the guests to Saginaw and assured them of the interest which citizens and business men took in the projects under their control, and gave them assurance of the support of the community into which they had come. Those who responded to the call of the toastmaster were Messrs. Clark, Hodenpyl, Walbridge, Stark, George B. Morley, Mershon, Humphrey, Winship, Hunsaker, Potter, Peter and Smith."

MR. W. H. HAYDEN has been appointed General Manager of the syndicate which controls the gas, electric light and railroad properties of Batavia, N. Y.

MR. "IRVY" MYERS and his associates seem to be rather slow in establishing the gas works which they so vehemently proposed last fall for the benefit of the residents of that ancient and honorable village of Long Island, known as Patchogue.

AT the annual meeting of the Reading (Pa.) Gas Company the officers elected were: Directors, Chas. Breneiser, William B. McIlvain, William A. Arnold, Isaac Hiester, John J. Kutz and William D. Smith; President, Wm. B. McIlvain.

THE increase in the output of the Holyoke (Mass.) Municipal Gas Works for May, 1903, as compared with the output for the corresponding month of last year, amounted to 11.2 per cent. The output for last May was 7,938,900 cubic feet.

A CORRESPONDENT in Merced, Cal., forwards the following: "The Merced Falls Gas and Electric Company will discontinue the giving away of electric lamps free of cost. The Company has already given thousands of lamps away during the last 5 years. This certainly shows a liberal spirit on its part, and I am surprised that it has lasted so long, especially as no other electric company gives away lamps free of charge. In all towns and cities in California electric lamps are sold to the consumers, but when a company has been so lenient as to extend a give away privilege for 5 years, it shows a liberality not often heard of." Indeed!

THE Committee of organization to direct the affairs of the International Congress of Electricity, that has been arranged for the Worlds' Fair at St. Louis, next year, is thus composed: President, Elihu Thomson; Vice-Presidents, Prof. H. S. Carhart, C. F. Scott, Prof. W. E. Goldsborough, Dr. W. S. Stratton; General Secretary, Dr. A. E. Kennelly; Treasurer, W. D. Weaver; Advisory Committee, B. J. Arnold, B. A. Behrend, C. S. Bradley, J. J. Carty, A. H. Cowles, Prof. F. B. Crocker, Dr. L. Duncan, H. L. Doherty, Prof. R. A. Fessenden, W. J. Hammer, C. Hering, L. B. Stillwell, C. P. Mathews, R. D. Mershon, K. B. Miller, Dr. W. J. Morton, Dr. E. L. Nichols, Prof. R. B. Owens, Dr. F. A. C. Perrine, Prof. M. I. Pupin, Prof. J. W. Richards, Prof. H. J. Ryan, William Stanley, Prof. C. P. Steinmetz and A. J. Wurtz. The duties of the organizing committee will be to prepare a programme for the International Congress of Electricity, to name the participants therein, to secure the ways and means for the conduct of the congress, and to promote general interest in the congress. The Exposition has set aside the week beginning Monday, September 12, 1904, for the meeting of this congress, and will at that time place at its disposal halls sufficient in number to accommodate the general sessions and department meetings.

THE AMERICAN GAS LIGHT JOURNAL

A. M. CALLENDER & CO.,
PROPRIETORS.

THOS. J. CUNNINGHAM,
ELBERT P. CALLENDER,
EDITORS.

CHAS. E. SANDERSON,
MANAGER.

PUBLISHED ON EACH MONDAY OF THE YEAR AT
No. 42 Pine Street, New York.
Telephone, 2996 John.

TERMS:

SUBSCRIPTION—Three Dollars per annum, in advance. Single copies, 10 Cents.

The JOURNAL is the official organ of the
NEW ENGLAND ASSOCIATION OF GAS ENGINEERS.
AMERICAN GAS LIGHT ASSOCIATION.
WESTERN GAS ASSOCIATION.
OHIO GAS LIGHT ASSOCIATION.

NOTIFICATION RESPECTING ADVERTISING.

Orders for new advertising, or for changes in standing advertisements, to insure attention in the issue following their reception, must be in hand any time of Wednesday.

AGENTS:

New York—American News Co., 39 and 41 Chambers St.
Germany—Lemcke & Buechner, of New York.
England—Aug. Siegle, 30 Lime Street, London.

MONDAY, JUNE 22, 1903.

The Market for Gas Securities.

The net result of the week's trading in city gas shares was all toward lower prices, the dull end of the game evidently having been influenced by the dealings in domestic and foreign moneys, depression in the list at large, and so on. Why these things should affect the price stability of a local industrial stock, of course, is beyond us. Gas manufacturers in this vicinity, however, have one or two comforting aids to sustain them. In the first instance oil is not as high (in price) as it was, and service gangs are quite busy, especially towards the East and West, north of the Harlem. Such recollections tend to confirm the baptized in the belief that quotations for city gas shares are at the point where prudent investors usually take a try. Consolidated is 193¾ to 194. Some people in New York have been trying to buy Mutual at 290. They have not secured of recent date much at that price.

Brooklyn Union, with next to no trading in it, is figured at 207 to 215. Certain Brooklyn capitalists (Mr. Leggett is not one of them) will see to it that it sells higher before the ides of September. Peoples, of Chicago, is fairly steady, and some in the know, or supposedly so, say that Indianapolis is a buy at quoted figures.

Gas Stocks.

Quotations by George W. Close, Broker and Dealer in Gas Stocks.

16 WALL STREET, NEW YORK CITY.

JUNE 22.

☞All communications will receive particular attention.

☞The following quotations are based on the par value of $100 per share.

N. Y. City Companies.	*Capital.*	*Par.*	*Bid.*	*Asked.*
Consolidated	$73,177,000	100	193¾	194
Central Union, Bonds, 5's	3,000,000	1,000	109	111
Equitable Bonds, 6's	1,000,000	1,000	105	..
" 1st Con. 5's	2,300,000	1,000	118	120
Metropolitan Bonds	658,000	..	108	112
Mutual	3,500,000	100	290	315
Municipal Bonds	750,000	..	..	
New Amsterdam Gas Co. ..				
Bonds, 5's	11,000,000	1,000	107⅛	108
Northern Union, Bonds, 5's.	1,250,000	1,000	106	107
New York and East River..				
Bonds 1st 5's	3,500,000	1,000	110	113
" 1st Con. 5's	1,500,000		109	111
Standard	5,000,000	100	131	..
Preferred	5,000,000	100	132½	..
Bonds, 1st Mortgage, 5's	1,500,000	1,000	115⅛	118
Yonkers	299,650	500	130	..
Out-of-Town Companies.				
Brooklyn Union	15,000,000	100	207	215
" " Bonds (5's)	15 000,000	1,000	119	119⅛
Bay State	50,000,000	50	⅛	¼
" Income Bonds	2,000,000	1,000	..	75
Binghamton Gas Works	450,000	100	28	30
" 1st Mtg. 5's	509,000	1,000	93	96
Boston United Gas Co.—				
1st Series S. F. Trust	7,000,000	1,000	82	85
2d " " "	3,000,000	1,000	47⅛	50
Buffalo City Gas Co.	5,500,000	100	7	10
" " Bonds, 5's	5,256,000	1,000	73	76
Capital, Sacramento	500,000	50	..	35
Bonds (6's)	150,000	1,000	..	..
Central, San Francisco	1,000,000	..	106	108
Chicago Gas Co. Guaranteed Gold Bonds	7,650,000	1,000	104	104¼
Cincinnati Gas & Elec. Co..	29,500,000	100	97⅛	98
Columbus (O.) Gas Co., 1st Mortgage Bonds	1,500,000	1,000	101	101⅛
Columbus (O.) Gas Lt. & Heating Co	1,682,750	100	88¼	89¼
Preferred	3,026,500	100	107⅛	109
Consumers, Jersey City Bonds	600,000	1,000	100	102
Consumers, Toronto	1,700,000	50	218	225
Consolidated, Baltimore	11,000,000	100	57	68
Mortgage, 6's	3,600,000	..	..	115
Chesapeake, 1st 6's	1,000,000	..	..	..
Equitable, 1st 6's	910,000	..	..	..
Consolidated, 1st 5's	1,490 000	..	..	112
Consolidated Gas Co. of N.J.	1,000,000	100	15	17
" Con. Mtg. 5's	880,000	1,000	85	87
Consolidated G. & E. Co.'s.				
Little Falls, N.Y.	90,000	100		100
Bonds	75,000	..	..	100
Detroit City Gas Co	4,825,500	50	..	89
" Prior Lien 5's	5,603,000	1,000	99⅛	100
Detroit Gas Co., 5's	982,000	1,000	77	79
" Inc. 5's	16,000	100	98½	100
Equitable Gas & Fuel Co., Chicago, Bonds	2,000,000	1,000	..	101
Essex and Hudson Gas Co.	6,500,000	..	39	40
Fort Wayne	2,000,000	..	..	..
" Bonds	2,000,000	..	55	..
Grand Rapids Gas Lt. Co. 1st Mtg. 5's	1,225,000	1,000	104⅛	105
Hartford	750,000	25	245	265
Hudson County Gas Co., of New Jersey	10,500,000	..	25	..
" Bonds, 5's	10,500,000	..	101	103
Indianapolis	2,000,000	..	60	70
" Bonds, 6's	2,650,000	..	102⅛	105
Jackson Gas Co	250,000	50	73	75
" 1st Mtg. 5's	290,000	1,000	101	102½
Kansas City Gas Light Co., of Missouri	5,000,000	100	..	36
Bonds, 1st 5's	3,822,000	1,000	102	104
Laclede, St. Louis	10,000,000	100	75	.
Preferred	2,500,000	100	92	..
Bonds	10,000,000	1,000	109⅛	110
Lafayette Gas Co., Ind.	1,000,000	100		60
Bonds	1,000,000	1,000	60	65
Louisville	2,570,000	50	130	140
Madison Gas & Elec. Co.				
" 1st Mtg. 6's	350,000	1,000	107½	108¼
" 6 per cent. scrip, due 1910	100,000	25	85	87
Montreal, Canada	2,000,000	100	218	184¾
Nashville Gas Lt. Co.	1,000,000	100	110	..
Newark, N. J., Con. Gas Co	6,000,000	..	56	58
Bonds, 6's	4,600,000	..	105	105¾
New Haven	1,000,000	25	300	325
Oakland, Cal.	2,000,000	..	46	47
" Bonds	750,000	..	..	.
Peoples G. L. & Coke Co., of Chicago	25,000,000	100	97¼	97⅜
Peoples Gas Lt. & Coke Co., Chicago, 1st Mortgage	20,100,000	1,000	..	..
2d "	2,500,000	1,000	104	
Rochester Gas & Elec. Co..	2,150,000	50	88	..
Preferred	2,150,000	50	118	..
Consolidated 5's	2,000,000	..	87½	90
San Francisco, Cal.	10,000,000	100	51½	52
St. Joseph Gas Co.				
" 1st Mtg. 5's	751,000	1,000	95	96⅛
St. Paul Gas Light Co	1,500,000	100	45	47
1st Mortgage 6's	650,000	1,000	113	116
Extension, 6's	600,000	1,000	113⅛	115
General Mortgage, 5's	2,465,000	1,000	92	93
Syracuse, N. Y.	1,975,000	100	42	45
Bonds	2,047.000	1,000	98½	99⅛
Washington, D. C	2,600,000	20	305	320
First mortgage 6's	600,000	..	..	..
Western, Milwaukee.				
Bonds, 5's	4,000,000	..	109½	110
Wilmington, Del.	600,000	50	232	..

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DIVIDEND NOTICE.

OFFICE OF THE UNITED GAS IMPROVEMENT CO.,
N. W. CORNER BROAD AND ARCH STS.,
PHILADELPHIA, PA., June 8, 1903.

The Directors have this day declared a quarterly dividend of 2 per cent. (one dollar per share), payable July 15th, 1903, to stockholders of record at the close of business, June 30, 1903. Checks will be mailed.

1462-5 LEWIS LILLIE, Treasurer.

Position Wanted.

A young man, 7 years' experience in all branches of the gas business, desires position as superintendent of distribution in small city, in the Middle West. Will take both distribution and manufacture in town of from 10,000 to 15,000 inhabitants.

Address, "SUPERINTENDENT,"
1463-1 Care this Journal.

WANTED,

Position as Manager of a Gas Company

That is much in need of a man thoroughly familiar with all details of the business. A position where the business and public confidence are much impaired, requiring the right man, at the right place, at the right time, preferred.

1462-tf Address, "ABILITY," care this Journal.

WANTED,

ASSISTANT SUPERINTENDENT.

A good, systematic man, who likes the business and likes work.

Address, "C. I.,"
1463-1 Care this Journal.

GAS MAKER WANTED.

A Gas Maker, Experienced in the Operating of a Lowe Water Gas Machine,

Will find steady employment and reasonable compensation, if on inquiry he proves the right sort of man.

1457-1 Address, "G. F. D.," care this Journal.

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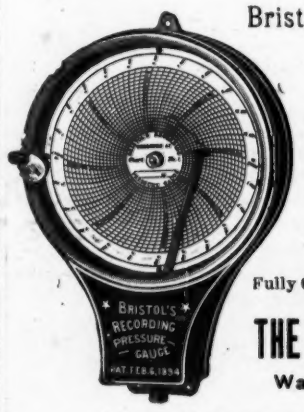

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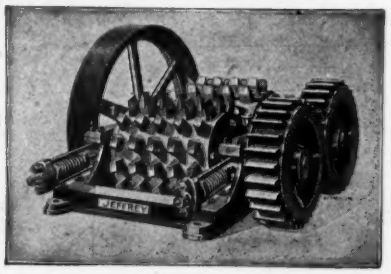

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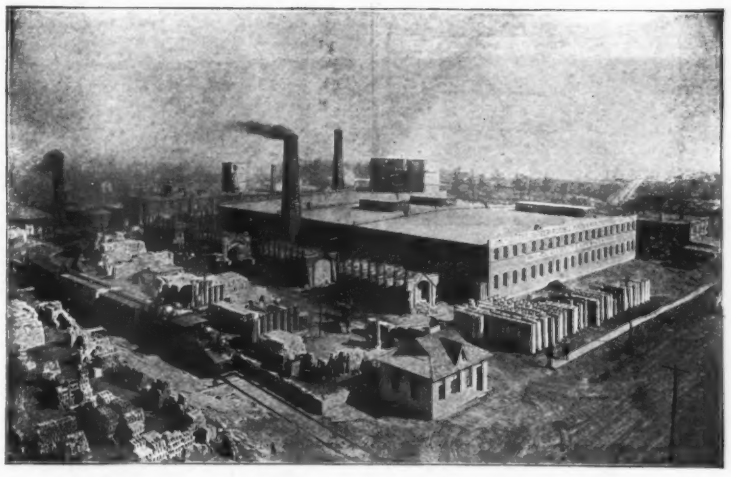

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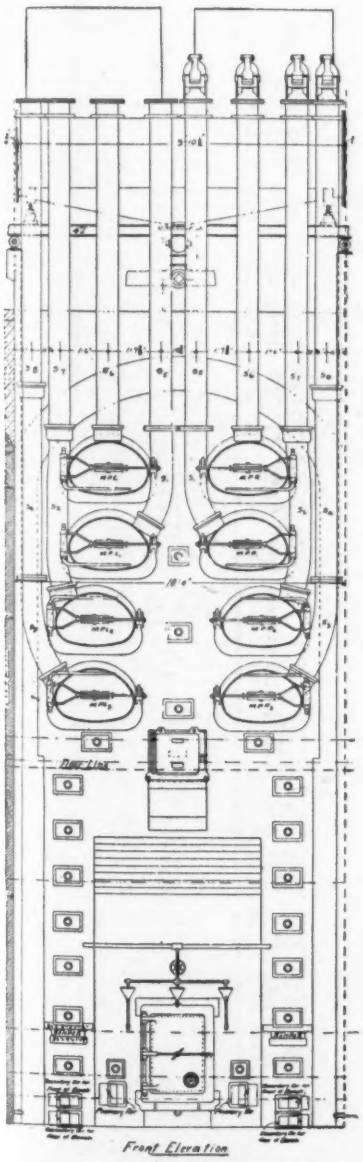

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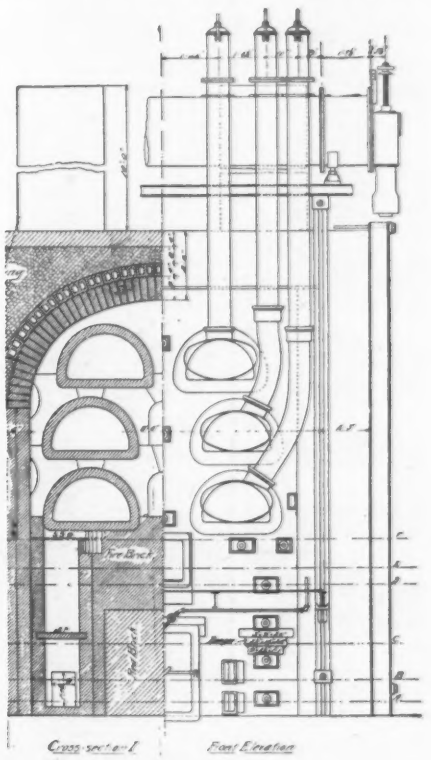

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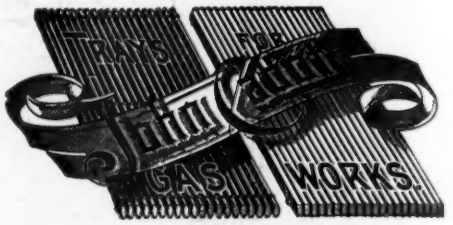

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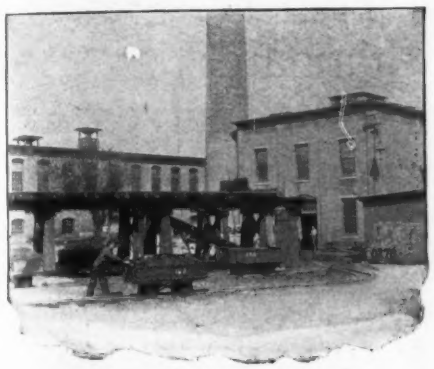

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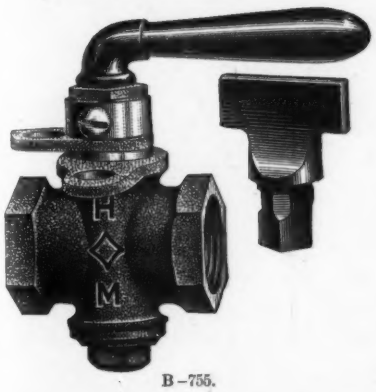

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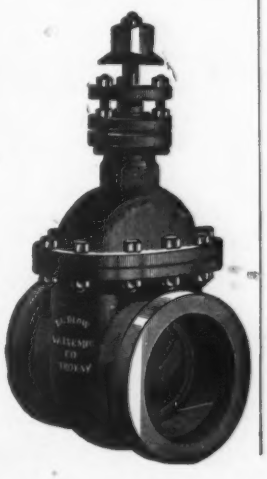

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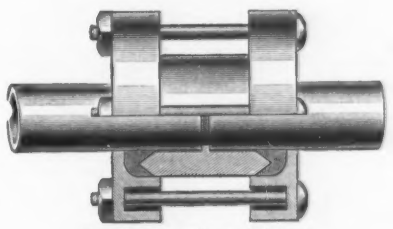

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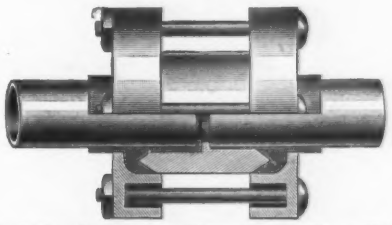

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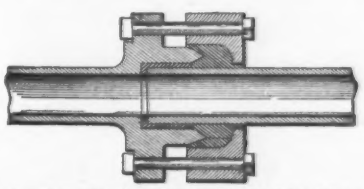

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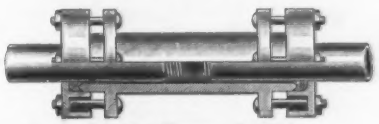

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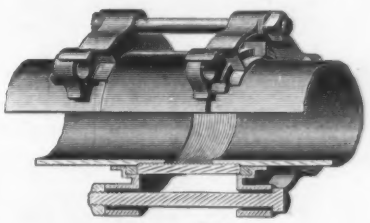

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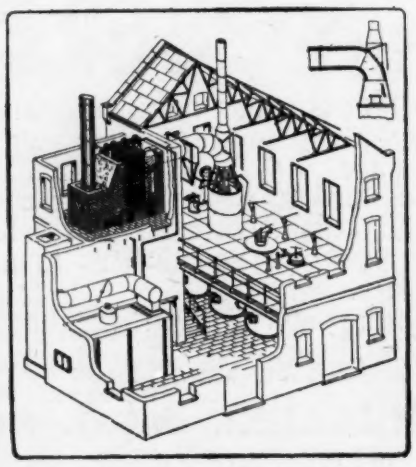

To absorb the heat now going to waste when you blow through your superheater to heat the feed water for your boilers to the temperature of the steam. This is now being done at the Poughkeepsie Gas Works, Poughkeepsie, N. Y. : : : : :

Write for full particulars how this is accomplished, the saving effected, and the advantages gained, to the

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Plans prepared and Estimates furnished at short notice.

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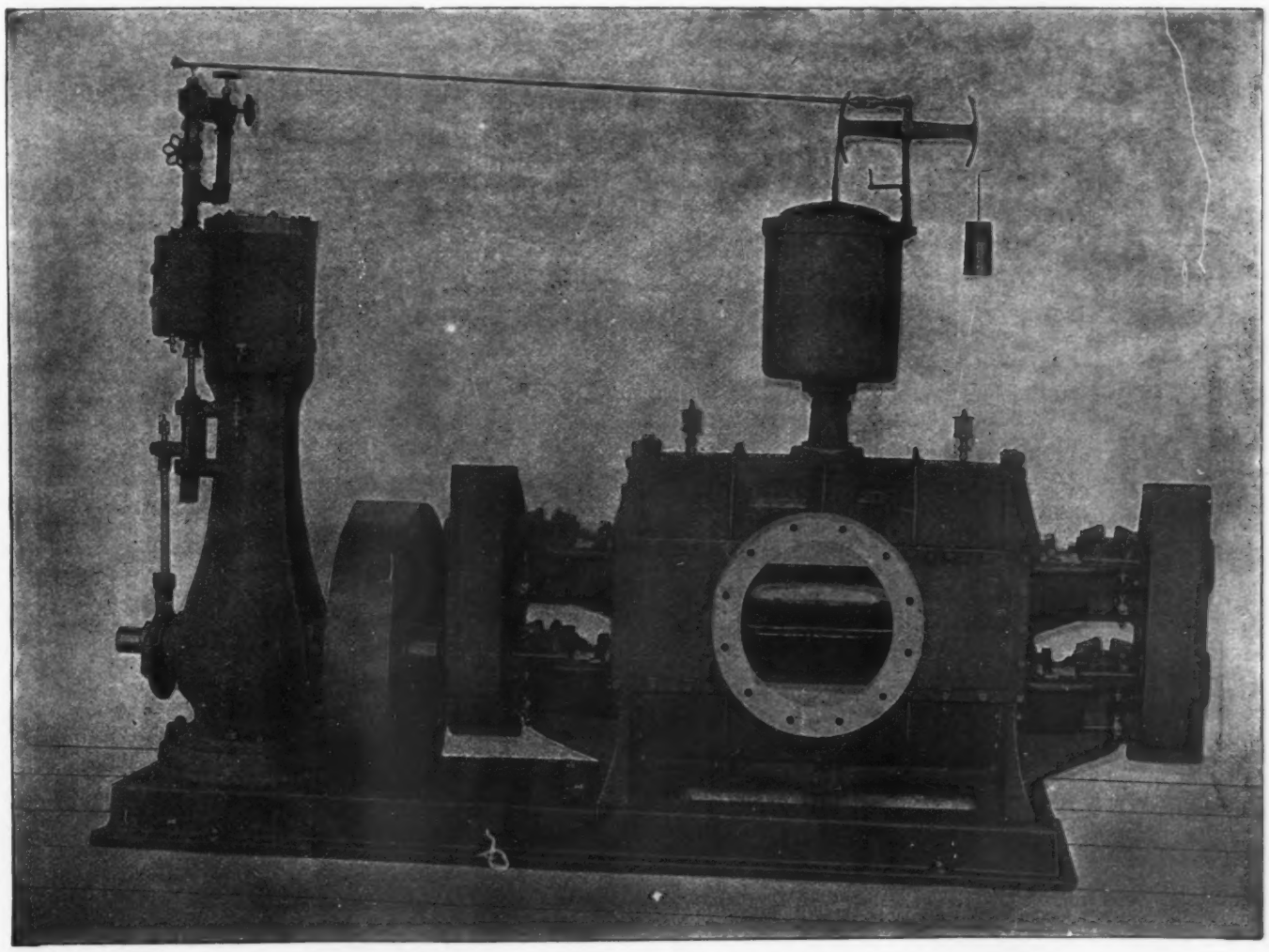
OUR GAS GOVERNOR IS MAKING FRIENDS EVERY DAY.



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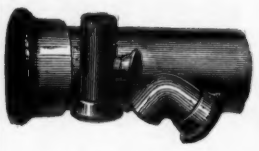

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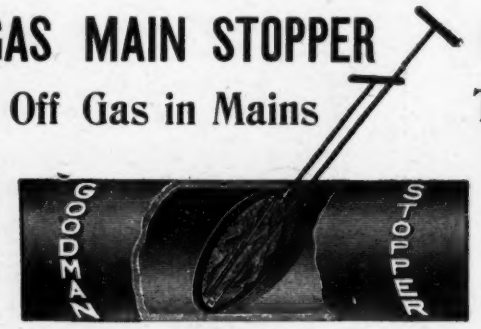
For Shutting Off Gas in Mains

Any size gas main can be shut off in 30 seconds. : : :



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Humphrey Crescent Instantaneous Water Heater

IS A QUICK SELLER.

PRICE,

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SHELF AND BRACKET FREE.

HAS NO EQUAL AT THE PRICE.

TRY ONE AND BE CONVINCED. WILL SEND ON 60 DAYS' APPROVAL.

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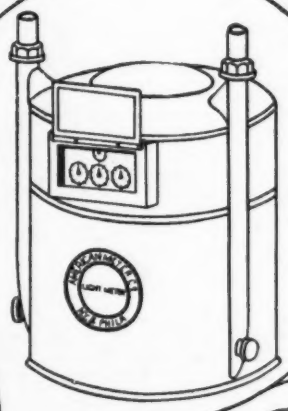
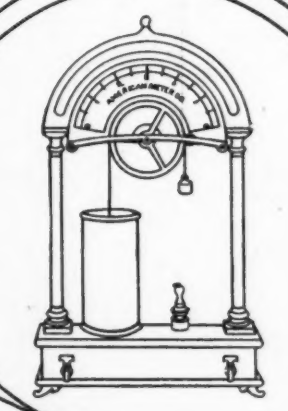
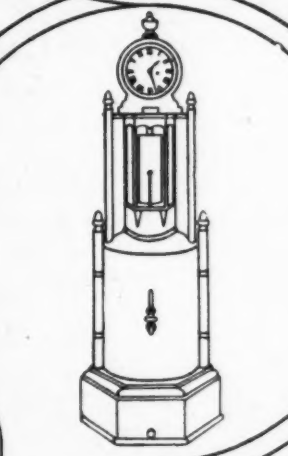
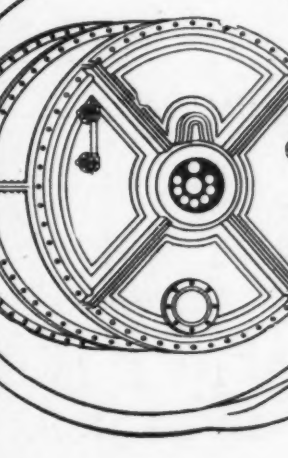




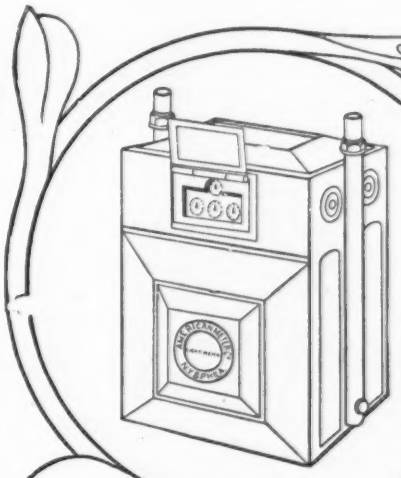


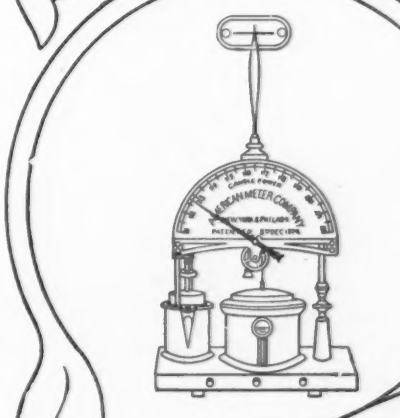


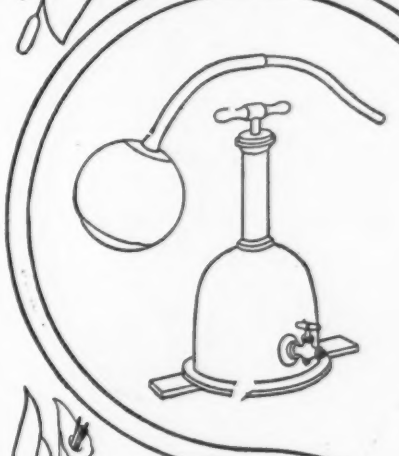
PUBLIC LIGHTING TABLE.

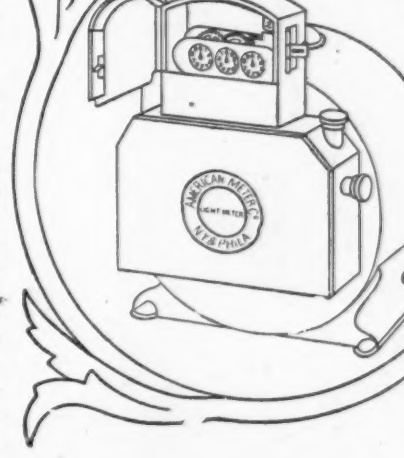
JULY, 1903.

Day of Week.	Date.	Table No. 1. Following the Moon. Light.	Table No. 1. Following the Moon. Extinguish.	Table No. 2. New York City. All Night Lighting. Light.	Table No. 2. New York City. All Night Lighting. Extinguish.
				P.M.	A.M.
Wed.	1	10.50 PM	3.30 AM	7.30	3.15
Thu.	2	11.20 PM	3.30	7.30	3.15
Fri.	3	12.00	3.30	7.30	3.15
Sat.	4	12.40 AM	3.30	7.30	3.15
Sun.	5	1.20	3.40	7.30	3.15
Mon.	6	2.10	3.40	7.30	3.15
Tue.	7	2.50	3.40	7.30	3.15
Wed.	8	No L.	No L.	7.30	3.15
Thu.	9	No L. PM	No L.	7.30	3.15
Fri.	10	No L.	No L.	7.30	3.15
Sat.	11	8.00 PM	9.30 PM	7.30	3.15
Sun.	12	8.00	10.00	7.30	3.15
Mon.	13	8.00	10.30	7.30	3.15
Tue.	14	8.00	11.00	7.30	3.15
Wed.	15	8.00	11.30	7.30	3.15
Thu.	16	8.00	12.00	7.20	3.15
Fri.	17	8.00 LQ	12.40 AM	7.20	3.15
Sat.	18	8.00	1.20	7.20	3.15
Sun.	19	7.50	2.00	7.20	3.15
Mon.	20	7.50	2.50	7.20	3.15
Tue.	21	7.50	3.50	7.20	3.15
Wed.	22	7.50	3.50	7.20	3.15
Thu.	23	7.50	3.50	7.20	3.15
Fri.	24	7.50 NM	3.50	7.20	3.15
Sat.	25	7.50	3.50	7.20	3.15
Sun.	26	7.50	3.50	7.20	3.15
Mon.	27	7.50	3.50	7.20	3.15
Tue.	28	7.50	3.50	7.20	3.15
Wed.	29	9.30	3.50	7.20	3.15
Thu.	30	10.00 FQ	3.50	7.10	3.30
Fri.	31	10.40	3.50	7.10	3.30









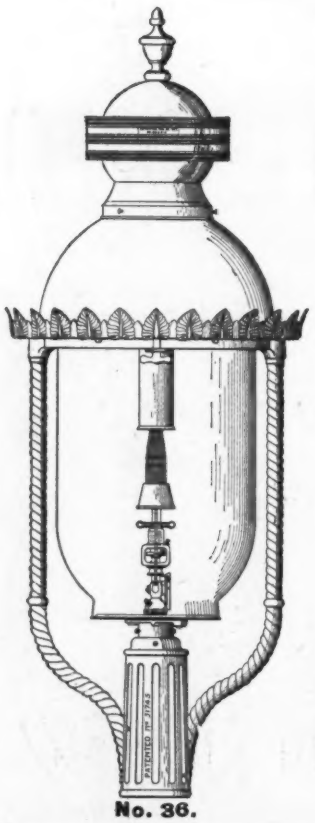
TOTAL HOURS LIGHTING DURING 1903.

By Table No. 1.	Hrs. Min.	By Table No. 2.	Hrs. Min.
January	245.00	January	423.20
February	192.00	February	355.25
March	201.00	March	355.35
April	167.20	April	298.50
May	152.00	May	264.50
June	131.00	June	234.25
July	140.40	July	243.45
August	156.20	August	280.25
September	171.20	September	321.15
October	198.20	October	374.30
November	216.30	November	401.40
December	232.10	Decsmber	433.45
Total, yr.	2203.40	Total, yr.	3987.45

NEW YORK, 33 Nassau Street. PHILADELPHIA, Broad and Arch Streets. CHICAGO, Foot of Orleans Street. BOSTON, 624 Tremont Building.
CLEVELAND, 809 Cuyahoga Building. ST. LOUIS, 712 Roe Building. SAN FRANCISCO, 712 Polk Street.

WELSBACH STREET LIGHTING COMPANY

.... OF AMERICA ....



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Welsbach System of Street Lighting,

Which includes its specially DESIGNED AND PATENTED BURNER for STREET and PARK LIGHTING exclusively.

Uniformly SUCCESSFUL in 150 Cities and Towns.

By means of the Welsbach System of street lighting the superiority of GAS over electricity for street lighting has been fully demonstrated.

POINTS OF MERIT:

It is { Economical, Attractive, Successful, Up-to-date.

IT LIGHTS THE STREET.

Where there are no gas mains we can furnish an equally good light by our SELF-GENERATING NAPHTHA WELSBACH BURNER, and thereby supply a uniform light in all localities.

Correspondence Solicited from Gas Companies and Others Interested in Municipal and Outside Lighting.

No. 38.

The Welsbach Gas Arc for Indoor Lighting.

The cut tells the story—but not all of it. Get one lamp and light it—then the tale's told from beginning to end. For one Welsbach Gas Arc Lamp is a better salesman than 20 pages of advertising.

Here's what it would show if you give it a chance to prove its worth:

1. A mechanical construction and finish that insures the greatest durability.
2. The renewal of mantles and the cleaning of globes without removal of globe.
3. The greatest amount of candle power with least consumption of gas.
4. A by-pass cock so constructed as to permit all or only one mantle burning at a time.
5. A pilot light that consumes but 1 foot of gas in 24 hours. Costs $\frac{1}{10}$ of a cent a day.

Give it a Chance to Tell its Own Story and it Won't Disappoint.

Let us send you one lamp—doesn't cost a fortune—and it will answer every question you put to it; make good on every test given it. You know the only proof of the pudding? What's the use in a fellow telling you it tastes good? Taste it yourself, then you know.

May we Send you ONE Lamp?

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THE UNITED GAS IMPROVEMENT COMPANY

During the Year 1902 has been Awarded Contracts in the Following Places for

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Belmar, N. J.	Indianapolis, Ind.	Oklahoma City, O. T.
Blue Island, Ills.	Jersey City, N. J.	Oneonta, N. Y.
Boonton, N. J.	Laconia, N. H.	Plainfield, N. J.
Brooklyn, N. Y.	Lakewood, N. J.	Portland, Me.
Carlisle, Pa.	La-Salle-Peru, Ills.	Pottsville, Pa.
Champaign, Ills.	Martinsville, Ind.	Scranton, Pa.
Coney Island, N. Y.	Memphis, Tenn.	South Brooklyn, N. Y.
Dallas, Tex.	Newark, N. J.	Suffern, N. Y.
Danville, Ills.	New Brunswick, N. J.	Swedesboro, N. J.
Des Moines, Ia.	New London, Conn.	Syracuse, N. Y.
Evanston, Ills.	New Orleans, La.	Washington, N. C.
Evansville, Ind.	Norfolk, Va.	Woonsocket, R. I.

TOTAL SETS, 1902, ... 51
TOTAL DAILY CAPACITY, 1902, . . 32,825,000 cubic feet.
TOTAL SETS TO DATE, ... 447
TOTAL DAILY CAPACITY, ... 299,670,000 cubic feet.

The United Gas Improvement Company,

Broad and Arch Streets, Philadelphia.

Established 1858. Incorporated 1890.
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FIRE BRICK . . .
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Standard Fire Brick and Gas Retorts.

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WORKS, Perth Amboy, N. J.
OFFICE, 418 to 422 East 23d St., N. Y.

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Sole Agents for New England States.

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President and General Manager.

MISSOURI FIRE BRICK CO.,

ESTABLISHED 1882.

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To Retain Fluid Material of Any Sort.

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STRICTLY High Grade. . . . .
Carefully Prepared.
For Gas Making or
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TEXAS PETROLEUM

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GAS OIL
A SPECIALTY

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KELLER ADJUSTABLE COKE CRUSHER.

Strong, Simple, Durable. Will Crush any Size Desired.

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as it gives this information accurately at sight, without mental effort. No calculations needed. Saves time, money and mistakes.

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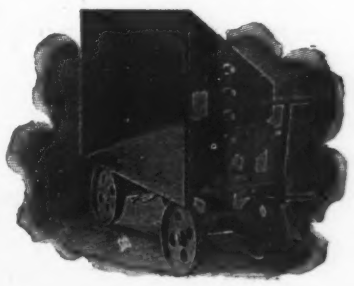

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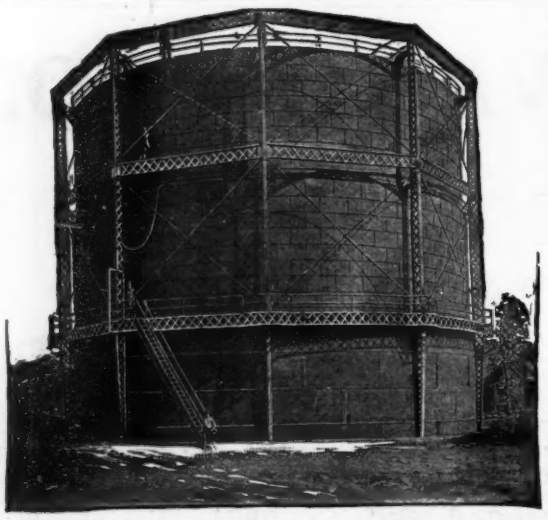

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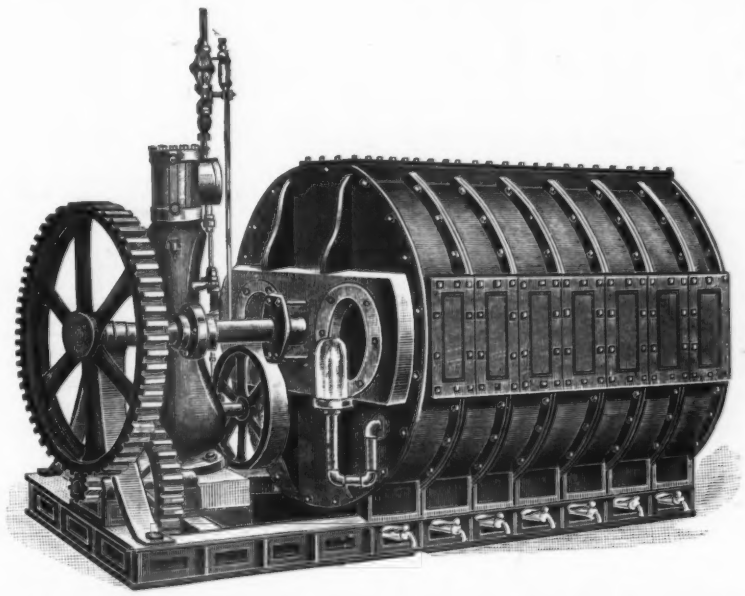

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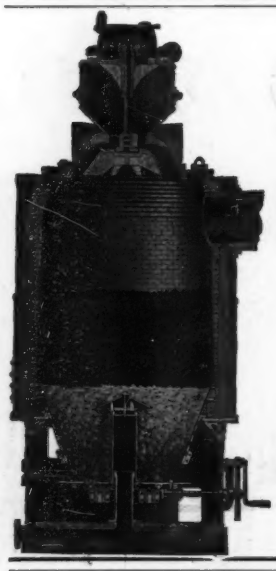

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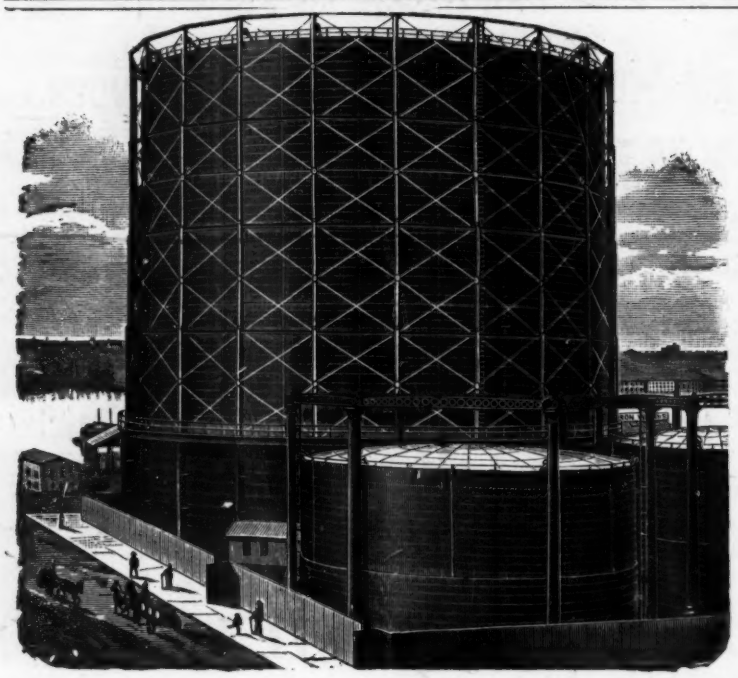

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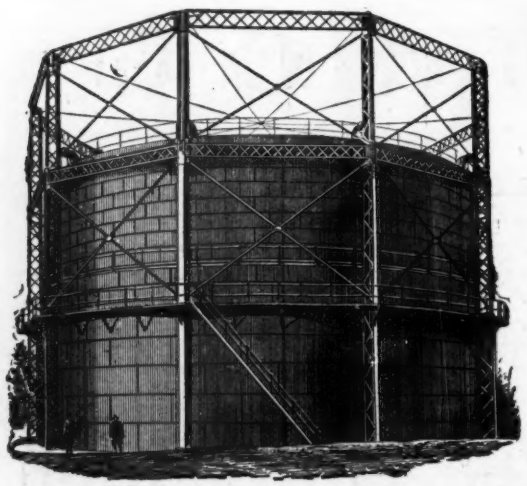

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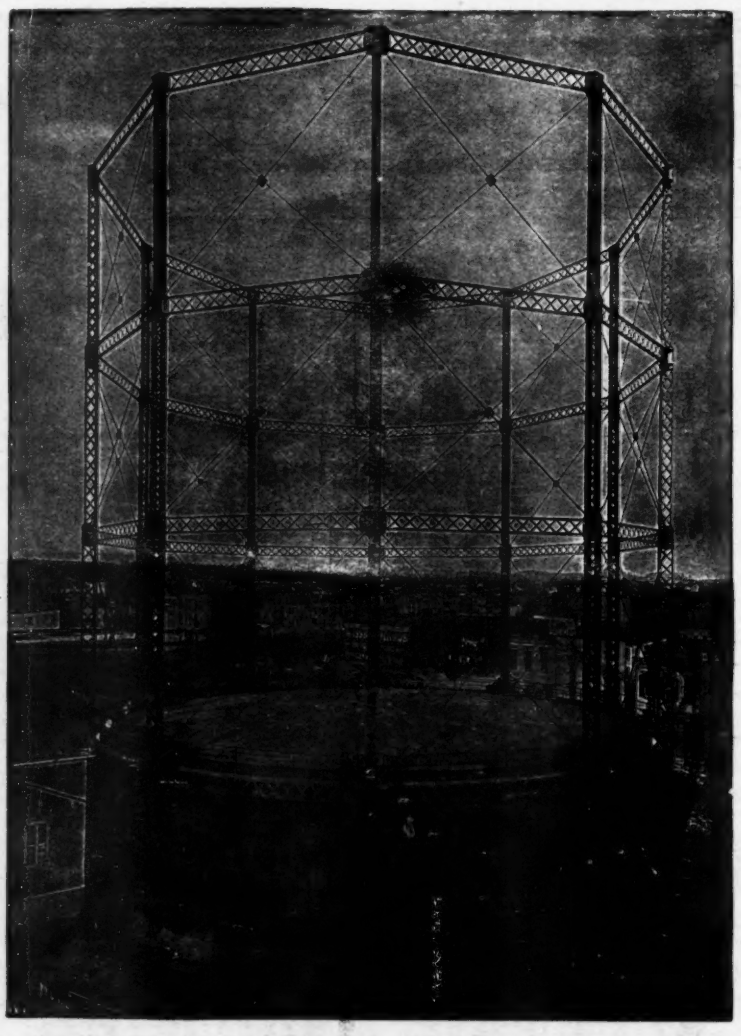

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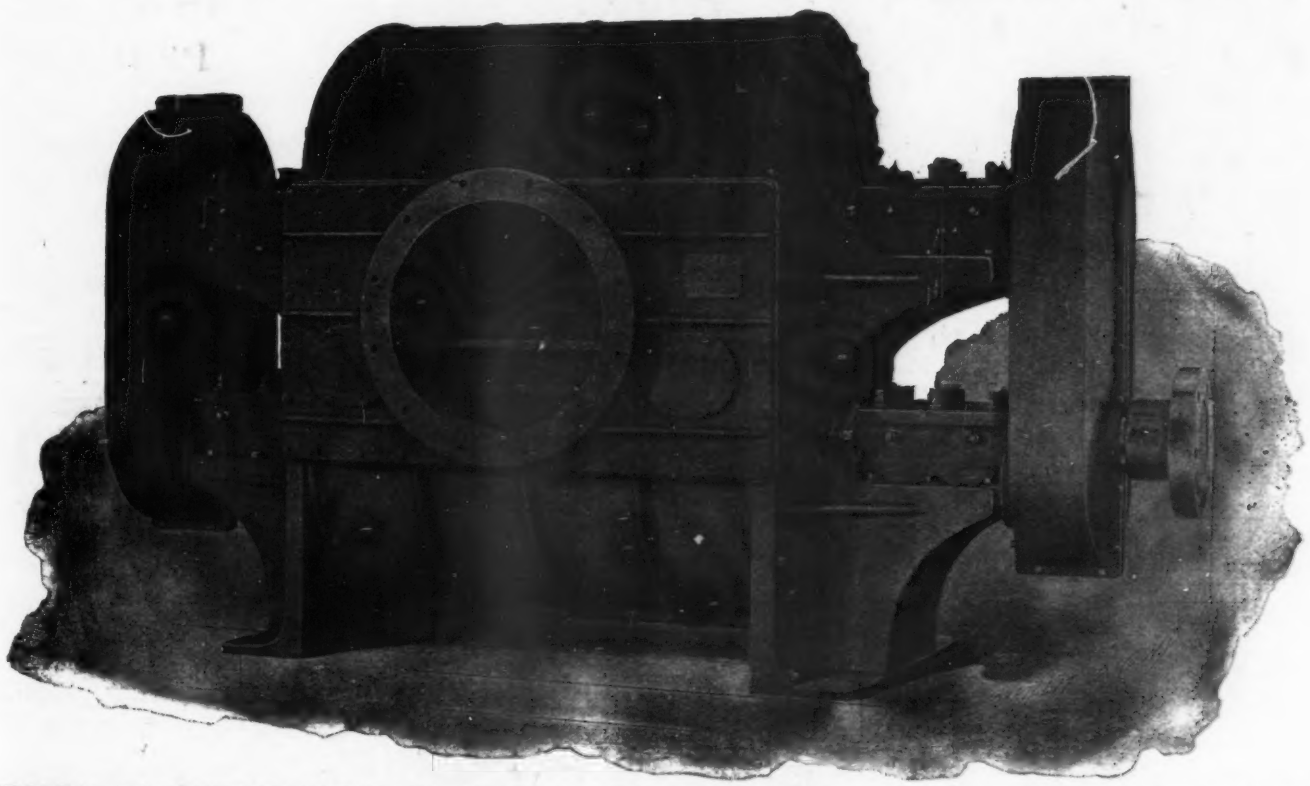

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